The color concept construction process in 8-10 year-old children

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ESERA 2023 Cappadocia TÜRKİYE

The 15th Conference of the European Science Education Research Association (ESERA)

August 28 - September 1, 2023, Cappadocia, Türkiye

Abstract Book

Compiled by

Metin Sardag & Gokhan Kaya

Hacettepe University STEM & Maker Lab, Türkiye

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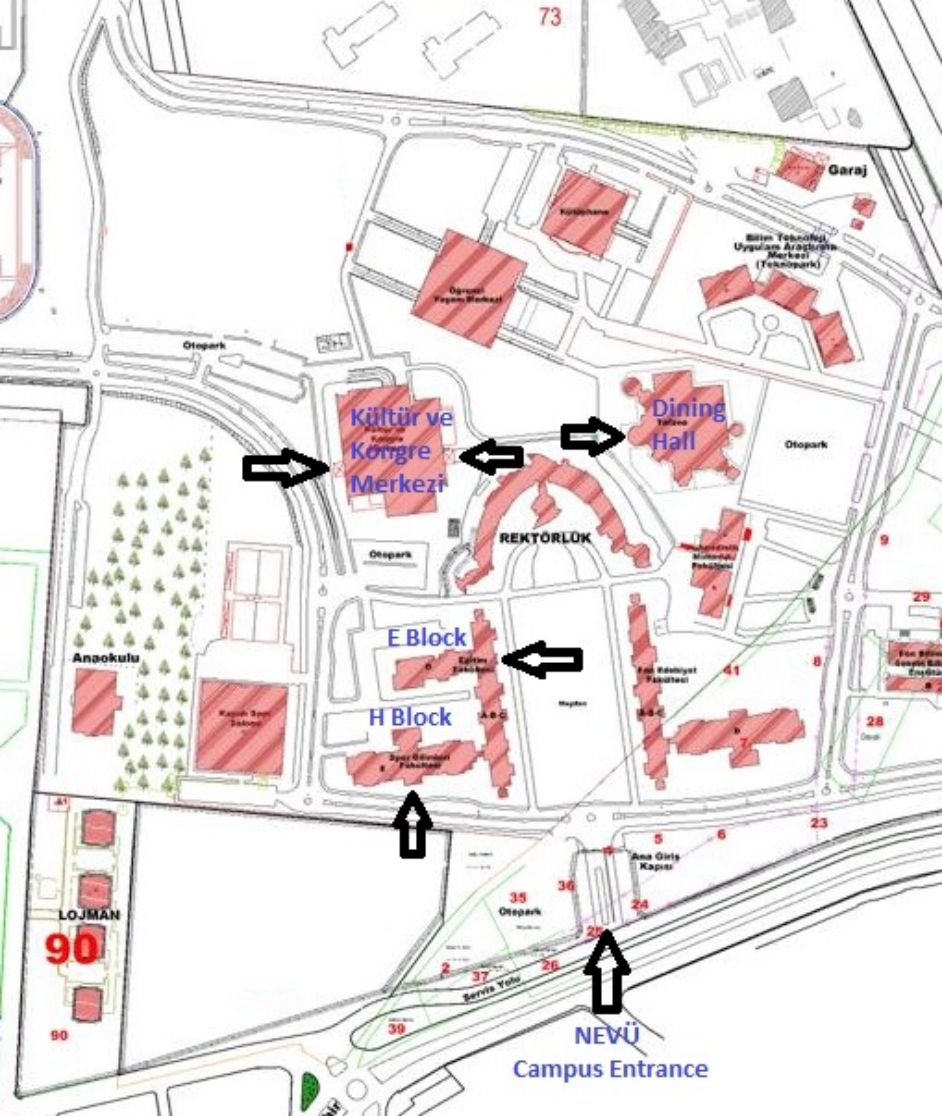
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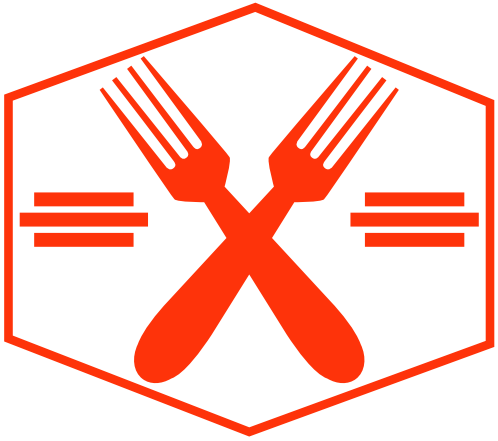

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WELCOME

Dear Participants of the 2023 ESERA Conference,

A warm welcome to the 15th Conference of the European Science Education Research Association (ESERA) in Cappadocia, Türkiye. This is our first physical conference following the Covid-19 pandemic, and as such it is a wonderful opportunity for the ESERA community to reconnect in person and to learn about our respective research across Europe and beyond. I would like to extend a special greeting to early career researchers and new members who will be joining the ESERA family during this conference. I hope that the event will be an intellectually stimulating and socially pleasant experience for all.

The planning of the conference began when we were still in the midst of the pandemic, slowly emerging from a very challenging period globally. The three universities involved in the organisation of the conference - Hacettepe University, Gazi University, and Nevşehir Hacı Bektaş Veli University - have provided enormous support throughout but it is important to note particularly the period following the devastating earthquakes in February 2023. On behalf of the ESERA Board, I thank the leadership of the Local Organising Committee, namely Gultekin Cakmakci, Mehmet Fatih Tasar, and Mustafa Hilmi Colakoglu for the effective management of the preparations under such extraordinary circumstances.

The theme of the conference is "Connecting Science Education with Cultural Heritage", one of the main goals of UNESCO, the United Nations Educational, Scientific and Cultural Organization. As a culturally diverse country with a rich heritage, Türkiye provides a brilliant context to consider research in science education in diverse social learning environments.

I hope that the conference will build on your professional networks and help enhance our understanding of improving science education through research. I wish you all a productive conference in Cappadocia!

Sibel Erduran

ESERA President

University of Oxford, UK

WELCOME

A very warm welcome to the European Science Education Research Association (ESERA). I hope this will be a major professional highlight for all of us.

The preparation for the conference began more than 2 years ago. We received around 1300 submissions. After a review process, we now have 695 Papers, 54 Symposia, 2 Panels, 20 Workshops, 150 Posters with 3 plenary speakers and 2 ESERA community plenary speakers. With on-site registration, we are expecting around 1100 participants.

As always ESERA supports early-career researchers. We think that everything needs to be done to keep their enthusiasm fresh and alive for developing a science education culture. Drawing upon that we are delighted to announce five workshops for early-career researchers and practitioners as part of the programme for the ESERA 2023 conference. That will bring fresh enthusiasm to the new and young generation of researchers and practitioners in STEM education around the globe.

Spanning Europe and Asia, it can be said that Turkiye has been the meeting place of many peoples and cultures throughout the centuries. Having colleagues from over 65 countries at this conference in Cappadocia, a historical region in Central Anatolia, has potential to show our way of mutual understanding, respect, and cooperation which is also much needed in today's world. Accordingly, the theme of this year's conference is "Connecting Science Education with Cultural Heritage".

The ESERA 2023 conference will be a success with your insights and inputs for the benefit of all conference participants and for science education around the world. We look forward to these valuable interactions and experiences, developing partnerships, and significant outcomes of this conference.

On behalf of the Local Organizing Committee of the ESERA 2023 Conference, I would like to thank everyone who has contributed to this conference in different capacities and wishes all participants a wonderful, rewarding, and successful conference.

Gultekin Cakmakci

ESERA 2023 Conference President

Hacettepe University STEM & Maker Lab, Türkiye

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Strand 8 – Scientific Literacy and Socio-scientific Issues

Maria Evagorou & Nadja Belova

Strand 9 – Science Education for Sustainability, Agency and Futures Literacy

Antti Laherto & Eliza Rybska

Strand 10 – Environment, Health, and Science Education

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Lorenz Kampschulte & Hakki Ilker Kostur

Strand 12 – Equity, Diversity, and Identity in Science Education

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Strand 13 – Science Curriculum and Educational Policy

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Strand 14 – Evaluation and Assessment in Teaching and Learning

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Strand 16 – In-service Science Teacher Education and Professional Development

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Strand 17 – Science Education in Primary and Pre-primary Learning Contexts

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Strand 18 – Teaching and Learning Science at Middle and Secondary School

Carla Morais & İbrahim Delen

Strand 19 – Teaching and Learning Science at the University Level

Federico Corni & May Lee

Strand 20 – Methods and Methodological Aspects in Science Education Research

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PROGRAMME

	August 28	August 29	August 30	August 31	September 1	
	Monday	Tuesday	Wednesday	Thursday	Friday	
08:30 – 09:00	Registration					
09:00 – 09:30	Pre-conference Workshops for Early Career Researchers	Parallel session 3 (Symposia)	Invited Panel 1	Parallel session 6 (Symposia)	Parallel session 10 (Symposia)	Workshop for ECR
09:30 – 10:00						
10:00 – 10:30			Coffee break			
10:30 – 11:00			Plenary Lecture 3			
11:00 – 11:30		Coffee break		Coffee break	Coffee break	
11:30 – 12:00		Plenary Lecture 2	General Assembly	Plenary Lecture 4	Invited Panel 2	Workshop for ECR
12:00 – 12:30	Registration					
12:30 – 13:00		Lunch (12:30-14:00)	Lunch (12:30-14:00)	Lunch (12:30-14:00)	Closing/Opening Ceremony	
13:00 – 13:30	Opening Ceremony				Virtual parallel sessions 1 (Papers)	
13:30 – 14:00	Plenary Lecture 1					
14:00 – 14:30		Parallel sessions 4 (Papers)	Guided Tour to Cappadocia	Parallel sessions 7 (Papers)		
14:30 – 15:00	Coffee break				Break	
15:00 – 15:30	Parallel sessions 1 (Papers)				Virtual parallel sessions 2 (Papers)	
15:30 – 16:00		Coffee break		Coffee break		
16:00 – 16:30		Parallel sessions 5 (Posters)		Parallel sessions 8 (Papers)		
16:30 – 17:00	Coffee break				Break	
17:00 – 17:30	Parallel sessions 2 (Papers)				Virtual parallel sessions 3 (Papers)	
17:30 – 18:00		Special Interest Groups (SIG)		Parallel sessions 9 (Posters)		
18:00 – 18:30						
18:30 – 19:00	Welcome Reception	Early Career Researcher (ECR) Reception				
19:00 – 19:30						
19:30 – 20:00				Conference Dinner		
20:00 – 20:30						
20:30 – 21:00						
21:00 – 21:30						

CONTENTS

Pre-Conference Workshop for Early Career Researchers - 2

09:00 - 12:00 Monday, 28th August, 2023

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911 New Languages for Science Education From the FEDORA Project: An Exploration of Futures' Thinking

Andrea Troncoso[1], Francesca Conti[1], Olivia Levrini[2]

[1]Formicablu, Bologna, Italy. [2]Alma Mater Studiorum - University of Bologna, Bologna, Italy

Abstract

This workshop will be an exploratory, hands-on session to collaborative create new languages for science education, utilising the findings of the FEDORA EU project, its Future Manifesto and its Framework for Unbound Languages. There is a recognised need for new languages and formats to enhance imagination, the capacity to talk about contemporary challenges and find ways to describe them, define them, and face them with creative solutions. FEDORA investigated, through research and co-creation, three blind spots in formal and informal science education. We will base the workshop on blindspot 2 and 3. Blind spot two focused on exploring and co-creating ideas and strategies to adopt new languages and formats in science education, and blind spot three focused on the need to incorporate futures' thinking. The workshop includes an introduction to the project, enhancing its findings related to interdisciplinarity, boundaries, sense-making & strange-making, a metaphor used throughout the project. We will closely look at the Future Manifesto and the Framework for Unbound Languages and invite participants to choose some of the Manifesto statements to link them to the framework and collaboratively sketch an activity that expresses a new language. This will enhance the sense of agency of participants and will contribute to scaffolding abilities to connect with the future. During the session, the connections and crossings between scientific knowledge with literary, artistic, narrative, and visual approaches will be stressed.

Pre-Conference Workshop for Early Career Researchers - 1

10:30 - 12:00 Monday, 28th August, 2023

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67 Publishing in Science Education Journals (Some Tips to Help You Succeed)

Ron Blonder[1], Sarah Carrier[2], Valarie Akerson[3], Sibel Erduran[4], Inbal Salomon-Hai[5]

[1]Weizmann Institute, Rehovot, Israel. [2]NCSU, Raleigh, USA. [3]Indiana University, Bloomington, Indiana, USA. [4]University of Oxford, Oxford, United Kingdom. [5]Weizmann Institute of Science, Rehovot, Israel

Abstract

This workshop is designed provide participants with a generic and basic introduction to the process of manuscript preparation and peer review, right through to publication, with specific reference to science education research journals. The session is designed for new scholars who may want to learn more about the process and how to improve their publication success. Some of the latest developments in journals publishing will also be covered. The workshop will be conducted in two parts. The first part will be a presentation from Science Education Journal Editors. During this segment, strategies for improving citation rates and information about journal indices will be shared. The second part will comprise a panel discussion where attendees will be able to quiz the Editors of science education journals about the process of publication in their journals. Finally, editors will be available to workshop participants for individual discussions about the best places to publish specific manuscripts.

Pre-Conference Workshop for Early Career Researchers - 4

10:30 - 12:00 Monday, 28th August, 2023

1321 STEM Motivation through Microcontrollers And Robots

Ian Galloway[1], Frederick Fotsch[2]

[1]T3 Europe, Pontivy, France. [2]Texas Instruments Education, Dallas, USA

Abstract

Microcontrollers are now ubiquitous and are to be found wherever scientists and technicians are needing to handle large streams of input data and control output devices according to the feedback. We will show you how easy it is to use such devices and be able to sense the environment. Most microcontrollers come with a range of built in sensors and of course are to be found in the operating systems of robotic devices. There is evidence to show that using robots is highly motivating and it is this which needs to be harnessed when used in science classes. Being able to collect data and analyse it is to do science and maths but to use the data in feedback and control systems is to give the student a full STEM experience. The word robot can be applied to any device which can control itself through sensors which provide feedback. Essentially this would mean that a simple device such as a thermostat is a robot. Washing machines and drones are both robots but the student more readily perceives the drone as being one. It is important that students understand how pervasive robotic technology has become today. The session should provide participants with material for their own research questions.

Pre-Conference Workshop for Early Career Researchers - 3

11:00 - 12:00 Monday, 28th August, 2023

1318 Out of Class (OOC) Experience

Eli Kalmanzon

Fourier Education, Rosh Ha'ayn, Israel

Abstract

Fourier is a worldwide leader in the field of science education technology for students from primary schools through high school, teachers training colleges and universities. Fourier provides a complete solution for a computerized lab, which includes:

1. Data logging devices with the einsteinTM tablet or einsteinTM LabMate (when another screen device is available).
2. Over 60 sensors covering most curriculum topics and an industry leading data collection.
3. Data collection and analysis software, MiLABEx.

The einsteinTM platform with its 3 sub-apps (The Lab, the Workbook, and the Weather Station), enables teachers and students to work and create content linked to experiments, share it, and perform an easy hands-on science learning from anywhere- in the classroom, in the greenhouse, in the field, next to any water source or from home. The einsteinTM platform supports new ways of teaching that focus on learners as active participants, linking science with everyday life, enabling personalized science education, increasing motivation, and making learning more fun and effective. In this seminar we will discuss the following topics:

- The benefits of Computerized science labs from everywhere.
- Collaboration with Greenhouses- as a model for science-based hand-on activity targeting environmental issues and finding new ways for solving food problems.
- Enjoy collecting data around us and our bodies as an example.
- MiLABEx unique features: Prediction tool, Video sink, Share to Compare, PDF viewing, Workbook & Weather Station.

Plenary Lecture - 1 by Ayelet Baram-Tsabari

13:30 - 14:30 Monday, 28th August, 2023

Chair: Sibel Erduran

1303 The (Lack of) Relevance of Science Education to Science-Informed Behavior

Ayelet Baram-Tsabari

Technion - Israel Institute of Technology, Haifa, Israel

Abstract

In recent decades, science education has become mandatory in many countries, under the assumption that it has value for everyday life, by supporting better, more logical, and informed science-related decisions. Paradoxically, the conjecture that science education helps people make evidence-based decisions, itself lacks direct evidence. In this talk, I will examine the limited empirical evidence relating to the relevance of science education to adult engagement with science in everyday life. Among other studies, I will present research testing for a possible correlation between the level of science education or scientific knowledge and science-based decision-making in the context of real-life COVID-19 dilemmas. I will show that the level of formal science education received did not significantly explain any of the variances in participants' adherence to social distancing guidelines or their use of health-related justifications for doing so. Science knowledge played a role in predicting adherence to social distancing guidelines. However, this relationship disappeared when other commitments dominated. Today, there is little evidence to support the claim, that science education, as done in the last decades, is useful for people's everyday engagement with science. Without a more nuanced and deeper understanding of science reasoning and use "in the wild" it seems we are tinkering toward utopia with little empirical grounding. Therefore, we need to pay more attention to how real people use real science knowledge in their real lives.

Parallel Session - 1.1 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair:Yaron Lehavi

21 Summary Lecture in Teaching Mechanics

Igal Galili[1], Ehud Goren[1,2]

[1]The Hebrew University of Jerusalem, Jerusalem, Israel. [2]Hadassah Academic College, Jerusalem, Israel

Abstract

We have developed a summary lecture which can be delivered after teaching of school course of mechanics. We were guided by the discipline-culture paradigm which organizes the curricular content in tripartite structure nucleus-body-periphery. Keeping in focus the major principles of mechanics, their meaning, the lecture specified the related components of the body knowledge and contrasted the principle of classical mechanics (Newton's laws of motion) with their historical alternatives (science cultural heritage), often appearing as students' misconceptions. The major features of classical mechanics as a fundamental scientific theory and its area of validity were emphasized. After experimental application, the impact of the lecture was assessed with respect to the knowledge maturity, quality and affective perception. The documented positive impact provides support to the practicing summary of major topics of school physics in terms of discipline-culture which serves as a delay organizer of knowledge improving its quality.

532 Embodiment and Scientific Expertise: A Contribution to a Process Model of Ontology

Tamer Amin[1], Mariam Yamout[2]

[1]American University of Beirut, Beirut, Lebanon. [2]University of Calgary, Calgary, Alberta, Canada

Abstract

In this paper, we engage with the literature on the role of ontology in science learning. There are two contrasting claims in the literature: one suggests that science learning involves a radical, ontological reclassification of concepts; another suggests that ontological categorization is a more dynamic phenomenon in both novices and experts. Using Knowledge Analysis and the perspective of embodied cognition (especially conceptual metaphor theory), we identify knowledge elements (reflected in language and gesture) activated by scientists' while solving problems dealing with the concepts of heat, electric current and light. We characterize the roles of these elements in constructing scientific concepts that fall within a constraint-based process

ontology. We view our findings as contributing to a process model of ontology with important pedagogical implications that draw from both ontological shift and dynamic ontologies perspectives.

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560 Teaching and Learning Floating and Sinking: A Meta-Analysis

Anastasios Zoupidis[1], Martin Schwichow[2]

[1]Department of Primary Level Education, Democritus University of Thrace, Alexandroupolis, Greece. [2]Pädagogische Hochschule, University of Education Freiburg, Freiburg, Germany

Abstract

Floating and sinking (FS) is a main topic in science education, both at primary and secondary levels. At the same time, the interpretation of FS phenomena is challenging because of the difficulty of the scientific concepts and explanatory models involved (e.g., density, buoyancy), along with students' everyday experiences which interfere with the scientific explanations. Consequently, in the last few decades, many studies investigated how to teach FS effectively to students of different ages utilizing multiple teaching approaches. This meta-analysis summarizes the findings from 69 intervention studies on teaching FS conducted between 1977 and 2021. Over all studies, we estimated a mean effect size of d = 0.85 (95% CI = 0.71, 0.99). Moreover, in a moderator analysis, we investigate the effect of design features, student characteristics, intervention characteristics, and assessment features on the mean study effect size. To analyze the effect of these moderator variables, we use a two-level hierarchical meta-regression model with robust estimations of standard errors for dealing with multiple effect sizes from single studies. We discuss the implications of our findings regarding the moderator variables for effective teaching of FS and further research on FS.

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984 What Can We Learn From the Case of Energy About Crosscutting Concepts in Integrated Science Education Curricula?

Yaron Lehavi[1,2], Avraham Merzel[2]

[1]The David Yellin Academic College of Education, Jerusalem, Israel. [2]The Hebrew University of Jerusalem, Israel

Abstract

Concepts used throughout the sciences (cross-cutting concepts, or CCCs) and meant to foster connections between topics that appear to be mutually unrelated were suggested as one of the pillars of an integrated K–12 science education curriculum. CCCs are expected to provide learners with organizational frameworks for connecting knowledge from the various disciplines into a coherent and scientific view of the world. For this purpose, such concepts must have a consistent meaning across the curriculum. However, CCCs are often defined and operationalized incompatibly in different disciplines. For example, the physical definition of energy, a core idea in all the scientific disciplines throughout the entire curriculum, as the ability

to do work, is not applicable as an organizing concept in the analysis of the biology of ecosystems or the function of the cell. Our research focuses on the image of energy as a CCC constructed by students and science teachers. A questionnaire composed of closed and open questions was administered to our subjects to examine how their concept images support them in making quantitative comparisons between processes belonging to different scientific domains. Our findings indicate a low level of consensus in each and across the two populations regarding their concept images as a CCC in this respect. Moreover, for many in both groups, the image of energy as having multiple types, especially when related to living creatures, inhibits such quantitative comparison. We also found that the image of energy as having an absolute value that can always be calculated or measured is, for many, the reason why such a comparison is possible. For some, mainly among the teachers, the image of energy change as being measurable via calorimetry provides the means to make quantitative comparisons between processes of different natures. Implications for curriculum planners and teachers' PD will be discussed.

Parallel Session - 1.2 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Bethan Stagg

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43 The Color Concept Construction Process in 8-10 Years-Old Children: Looking for Operational Invariants

Gabriel Dias de Carvalho Junior[1,2], Andressa Xavier Zinato de Carvalho[3]

[1]University of Namur, Namur, Wallonie, Belgium. [2]Catholic University of Louvain, Louvain-la-Neuve, Wallonie, Belgium. [3]City hall of Ponte Nova, Ponte Nova, Minas Gerais, Brazil

Abstract

This paper was a result of a longitudinal research which is still on course. This research counted with 63 children, students in a public school, from 8 to 10 years old in Minas Gerais state (Brazil). Our goal was to identify which operational invariants were used by the children on a color/ shadow construction situation through the use of a projector. We considered the solutions proposed by the children and also their own graphic notation. We've chosen Vergnaud's Conceptual Fields theory to identify the operational invariants. The conclusions point out that the understanding of colors by the children is a result of a differentiation between shades of brightness and dark. Our contribution relies on the new feature brought to Conceptual Fields theory's analytical framework which is the ability to evaluate the colors' conceptualization process in children.

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485 A Human Orrery to Help 11 Years Old Students Investigate the Shape of Planetary Orbits

Emmanuel Rollinde[1,2], Clément Maisch[1,2]

[1]CY Cergy Paris Université, Cergy, France. [2]LDAR, Paris, France

Abstract

We present a learning session designed around the use of a Human Orrery, a realistic representation of the solar system. Moving on the Human Orrery, students play the role of celestial objects such as the internal planets and a comet. By moving along the orbits, 11 years old students should notice and then explain the non-circular attribute of the orbits of planets. The Didactics Engineering has been mobilized to design the session following several didactical variables such as: the size of the Orrery, the eccentricities of the orbits or the proposed instruments. During the session, students make hypothesis, define protocols to prove their hypothesis and discuss the measures they obtain to confirm or discard their hypothesis. In the course of this modelling process, the circulation of their conceptions of a circle have been analysed. The observations of three classrooms involved in this session indicate that the students change from a continuous image of the circle, related to visual estimation and drawing with a pair of compasses, to a discrete understanding related to the definition of a circle as the set of points at equal distance from a centre. This session, led by two researchers of physics education for the research presented here, has also been implemented by science teachers with the same efficiency and conclusions.

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736 The Effect of Simulation-Integrated Online POE Activities on Preservice Science Teachers' Conceptual Understanding of Simple Electric Circuits, Attitudes, and Physics Self-Efficacy Beliefs

Seda Altunsoy Okvuran, Nejla Yürük

Gazi University, Ankara, Turkey

Abstract

The purpose of this study is to examine the effects of online POE-based teaching activities integrated with simulations on preservice science teachers' conceptual understanding, and attitudes towards simple electrical circuits, and self-efficacy beliefs in physics. The participants of the study who were studying in a state university in Turkey constitute 29, fourth grade preservice science teachers. Quantitative research was conducted in accordance with the one-group pre-test-post-test experimental design. "Simple Electrical Circuits Diagnostic Test (SECDT)", "Attitude Scale Towards Simple Electrical Circuits (ASSEC)", and "Physics Self-Efficacy Scale (PSS)" were applied to preservice science teachers as pre-test and post-test. In the online courses conducted with the Zoom application, preservice teachers performed POE tasks, group, and class discussions online, and made their observations of simple electrical circuits using PhET simulations. The results indicate that the simulation-integrated online POE activities improved conceptual understanding of preservice science teachers about simple electrical

circuits and had positive effects on their attitudes towards this subject and their physics self-efficacy. The frequency of the misconceptions revealed in the pre-SECDT and post-SECDT was also provided.

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991 UK Teachers' Knowledge, Attitudes, and Perceptions About Native Animal and Plant Species

Bethan Stagg

University of Exeter, Exeter, United Kingdom

Abstract

Biodiversity topics feature in UK primary and secondary science and geography curricula, providing a valuable opportunity for increasing children's ecological literacy. Studies in other countries have shown that teachers have poor species identification skills, but this topic has not been investigated for the UK. 90 primary and secondary geography and science teachers completed an online survey about knowledge and attitudes from 10/12/22 to 29/1/23. Recall (based on a free listing exercise) was highest for flowering plants, comparable for mammals and birds, and low for invertebrates and other vertebrate groups. Identification knowledge was highest for birds, comparable for mammals and flowering plants and low for invertebrates. There was a positive relationship between an individual's appreciation of nature and species knowledge. Respondents found colourful species attractive but species that could bite or sting unattractive. They believed that it was important for teachers to have identification skills and that children's identification knowledge was poor. I discuss the educational implications of the findings and effective interventions for increasing interest and awareness about plants and invertebrates with pre-service and in-service teachers.

Parallel Session - 1.3 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Rita Krebs

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79 A Guide for Students to Develop Escape Rooms on their Own in the Science Classroom

Chantal Lathwesen, Ingo Eilks, Käthi Neufeld

University Bremen, Bremen, Bremen, Germany

Abstract

Educational escape rooms are a popular, game-based learning method to acquire or apply knowledge and interdisciplinary skills. Therefore, a large number of escape rooms have been

developed for any educational level and subject content in recent years. Besides participating in an escape room, developing escape rooms is considered an effective method for students. For teachers, there are already some models that help them design a successful escape room for their own learning group. As of yet, no guide or framework for student-developed escape rooms exists. The guide presented below, can be used by students to develop their own educational escape games. It is based on the existing models for the teachers and consists of an explainer video, a prezi presentation and checklists. It can be used from grade 5 at the end of a unit to review what has been learned in a creative way or to make newly acquired knowledge available to other persons through the developed escape games. The first trial was successful and indicates that content knowledge, collaboration, creativity and communication can be promoted this way.

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406 The Effect of Reverse Engineering Practices Supported by the CORT Thinking Program on the Scientific Creativity of 6th Grade Students

Furkan Aydın[1], Hilal Aktamış[2]

[1]Aydın Adnan Menderes university, AYDIN, Turkey. [2]Aydın Adnan Menderes University, AYDIN, Turkey

Abstract

In this study, it is aimed to examine the effects of reverse engineering applications supported by the Cort thinking program on the views about reverse engineering of 6th grade students and in their scientific creativity and within the scope of the "Matter and Heat" unit. The study group of the research consists of 46 (23 experimental, 23 control) 6th grade secondary school students studying in the 2022-2023 academic year. During the research process, the lessons in the control group are taught in accordance with the constructivist approach methods and techniques and in line with the achievements of the Ministry of National Education. The practices in the control group are continued in the order included in the 2018 Science course curriculum. The same lessons taught in the control group are taught with the students in the experimental group. In addition, activities involving reverse engineering applications supported by the Cort thinking program are carried out. In order to collect data in the research; The "Scientific Creativity Scale" developed by Adey and Hu (2002) and adapted into Turkish by Aktamış (2007) and the "View Scale for Reverse Engineering Applications" developed by the researcher are used. In the research, the critical decision value will be chosen as $\alpha=0.05$. Since the number of participants in the groups is small ($n<30$), non-parametric tests will be used. To determine the quantitative findings, Mann Whitney U test will be performed to examine the differences in the pretest and posttest results according to the groups. Wilcoxon sign test will be used to examine whether the pretest and posttest to be applied are different. In addition, correlation analysis will be performed to examine the level of relationship between pre-test and post-test results according to the groups.

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918 "Acids, that Green Liquid Stuff, and Bases, Whatever Those Are?" – Teaching About Acid-Base Reactions in Upper Secondary School

Rita Krebs[1], Marvin Rost[1], Elisabeth Hofer[2], Anja Lembens[1]

[1]University of Vienna, Vienna, Austria. [2]Leuphana University Lüneburg, Lüneburg, Germany

Abstract

Acid-base chemistry plays an important role in our lives because of its real-world applications (industrial processes including acid-base reactions, everyday products containing or consisting of acidic or basic compounds, …). Consequentially, the topic is an important one in chemistry education. However, in the classroom, historical acid-base concepts clash with modern-day applicability, as their history is chiefly characterised by contradictory discoveries. Therefore, designation of what is an acid or a base remains ambiguous; everyday language, historical concepts and modern concepts of acid-base reactions lead to inconsistencies in teaching and model confusion amongst the learners. In order to relate the macroscopic everyday experiences of the learners to acid-base reactions with the processes on the submicroscopic level and to better embed acid-base reactions into the concept of chemical reactions in general, the Brønsted-Lowry acid-base concept was adapted accordingly for upper secondary students in the Design-Based Research project presented here. The focus in the adaptation is on the compatibility of acid-base reactions to other donor-acceptor reaction types (e.g. redox reactions). By means of Educational Reconstruction, key ideas (KIs) were identified as the central aspects of the topic for the target group. An explanatory framework based on the aforementioned key ideas was presented to upper secondary school students so as to evaluate acceptance, plausibility and applicability in three rounds of interviews employing the method of probing acceptance (N1=7, N2=4, N3=7). The results of these assessments were then used to design a teaching-learning sequence (TLS), which was evaluated using Rasch-scaled acid-base knowledge testing in an intervention study (N4=52). Overall, the results from both the preliminary investigations and the intervention study demonstrated the feasibility and usefulness of the chosen approach for local upper secondary students and thus contribute to the literature of how to teach about acid-base reactions.

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727 Identifying Science Teachers' Flexible Inquiry Understanding

Özden Bilge ÇALIM, Zeki BAYRAM

Hacettepe University, Ankara, Turkey

Abstract

It is seen that the approach on which the 2018 MONE (Turkey) Science Curriculum is based is an inquiry based learning approach. Science teachers are also expected to guide the course process in accordance with this approach. In this study, interviews are conducted with the teachers in order to determine the flexible understanding of inquiry that science teachers have. In the interviews, a series of questions are asked in order to reach the flexible inquiry understanding of science teachers. During the interview, teachers are expected to express their

practices by giving concrete examples instead of idealizing their understanding by going through concrete examples. For this reason, teachers were asked to describe in as much detail as possible whether they practiced especially according to inquiry based learning approach, and if they did, their most recent practices. A descriptive analysis of the answers of the teachers will be made in the interviews. While analyzing, teachers care will be taken to determine the purpose of the inquiry, to create expression levels, to determine the task sequence, to use the FIBST sequence, to decide who will have the task responsibilities, to create task responsibility alternatives, to guide the teacher in the course process and to create the didactic contract rules. As a result of the interviews, it is expected that some science teachers will not have a flexible inquiry understanding, while some teachers are expected to have a flexible inquiry understanding. In addition, it will be determined what is missing in the understanding of teachers who do not have a flexible understanding of inquiry.

Parallel Session - 1.4 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Eduardo Mortimer

1032 A Translation Device to the Study of Semantic Gravity in Chemistry Texts

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Abstract

In the instructional discourse of Chemistry education, it is important to investigate how the scientific knowledge is connected to other kinds of knowledge, as the daily knowledge. In this article, we use Semantic Gravity (SG) to study the connection between these different types of knowledge in the Chemistry discourse of a large-scale assessment items. SG is related to the degree of abstraction of knowledge and it can be defined by the level or degree to which a meaning relates to a context. In order to study the variation of SG in Chemistry texts we developed an analytical instrument or translation device using Chemistry items of a large-scale assessment as empirical data. Through our analysis we identified five semantic profiles. They are:1) the semantic waves; the 2) upper and 3) lower flatline profile; and the 4) rising and 5) falling half-wave profiles. These semantic profiles allow us to understand the variations in SG throughout the discourse presented in the Chemistry items, which is, in the different ways in which chemical knowledge is related to some context.

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896 Effects of Student-Generated Contexts on Functional Chemistry Concept Understanding

Edwehna Elinore Paderna

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Abstract

The study investigated the effects of Collaborative Student-Generated Contexts Teaching Approach (CSCTA) and Individual Student-Generated Contexts Teaching Approach (ISCTA) on functional concept understanding in chemistry. The study employed a quasi-experimental three-group pretest-posttest design. It involved 96 Grade 10 students in a laboratory school in the Philippines. The researcher taught all three classes using differentiated but parallel lesson plans, with the student-generated contexts teaching approach model as intervention. The three classes were exposed to one of the teaching approaches, namely: ISCTA, CSCTA, and Conventional Teaching Approach (CTA). The researcher developed the Functional Concept Understanding Test (FCUT), which was then validated by a panel of experts, pilot tested, and administered as pretest and posttest. One-way Multivariate Analysis of Variance (MANOVA) was done to examine the differences among the three classes in terms of functional concept understanding and its components. The student-generated contexts teaching approaches were effective in improving functional concept understanding in terms of enhancing cognitive elaboration, but not of experiential knowledge. It was found that the mean posttest score in the components of functional concept understanding, taken simultaneously, of students exposed to CSCTA was significantly higher than the mean posttest scores of students exposed to ISCTA and to CTA. Chemistry teachers can implement the Student-Generated Contexts Teaching Approach (SCTA) to improve the functional concept understanding of students. Chemistry educators can use the CSCTA to increase students' cognitive elaboration. The sharing of contexts during context generation gives opportunity for students to explain and make others explain as well as link different units of information.

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753 Students' Reasoning on the Dependence of Energy and Structure in Chemical Reactions

Benjamin Pölloth

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Abstract

The dependence of energy on the chemical structures is central for research in chemistry. However, empirical studies show that students' conceptual understanding in the area of energy is rather low. The aim of this study is to investigate which mental resources high school students use to reason about kinetic and thermodynamic aspects of chemical reactions. In a qualitative interview study, 38 high school students from 11th to 13th grade in 16 focus groups were asked to explain the role of energy in the reaction of hydrogen and chlorine to a tutoring student. Qualitative content analysis of the interviews shows that students use a broad variety of

cognitive resources to rationalize energy changes. However, many students focussed on technical terms and argued rather on the system level than on the level of single particles. Only very rarely, students connected energetic aspects with changes of chemical structures and bonds. This is also reflected in the prevailing interpretation of reaction coordinate diagrams as representations of energy changes in a system during the time of a reaction. The driving force of the reaction seems to be out of the scope for many students and was most dominantly explained by the octet rule. The results indicate a need to develop new learning and teaching approaches to strengthen the mental connection between energetic and structural aspects in chemical reactions.

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76 Significant Learning of Exoplanetology and Habitability

Gian Michaelsen, Agostinho Serrano

ULBRA, Canoas, Rio Grande do Sul, Brazil

Abstract

This research aimed to didactically transpose the concepts related to Exoplanetology and Habitability to High School. The transposition was successfully carried out resulting in the development of a didactic guide that served as a tool for students to analyze real data from a real exoplanet and infer its habitability. In addition to the didactic guide, foot and post tests and an interview that will feature unprecedented problem situations were carried out. The data collected from the performance of the students' activities were analyzed using Textual Analysis by Laurance Bardin and through it, evidence of maximum transformation of knowledge in the problem situations carried out by the students was identified. As brought by the theory of meaningful learning, the maximum transformation of knowledge is a strong indication of its meaningful learning.

Parallel Session - 1.5 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Ehud Aviran

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670 Added Value of Google Lens for Identification of Marine Organisms

Vida Lang[1], Andrej Šorgo[1,2]

[1]University of Maribor, Faculty of Natural Sciences and Mathematics, Maribor, Slovenia. [2]University of Maribor, Faculty of Electrical Engineering and Computer Sciencety of Electrical Enginering and, Maribor, Slovenia

Abstract

Biodiversity can be recognized as a natural and cultural heritage that must be preserved. In field work with organisms, everything begins with their identification, and traditionally identification keys have been used in dichotomous and pictorial form. With the advent of mobile devices, new forms of identification based on image recognition and artificial intelligence have emerged. The 83 students were given the task of identifying marine organisms using the book, the Internet, and the smartphone application Google Lens. After completing the task, the differences between the three methods were evaluated. We did not find any significant differences in the quality of species identification, so all methods can be used interchangeably. Based on their experiences with all methods, students determined that the least difficult method for identifying marine organisms was using the book and the most difficult method for identifying marine organisms was using the Google Lens application. It was found that students preferred the Google Lens application even though they found it to be the most difficult method. The added value of the Google Lens application is that it is always accessible on smartphones. The students expressed great satisfaction with the experience of the workshop.

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325 The Effects of Inquiry-Based Learning in a Virtual Learning Environment

Hasan Ozgur Kapici

Bogazici University, Istanbul, Turkey

Abstract

Technology developments also affect instructional technology such as computer simulations, virtual laboratories, and online assessment tools. The current study aims to investigate the effectiveness of an inquiry-based learning approach in a classroom and virtual setting on seventh-grade students' conceptual understanding and inquiry skills. A total of 156 students participated in the study. While the students in the control group received instruction in a real classroom environment, the students in the experimental condition used computer-based learning environments. Data was gathered through conceptual understanding and inquiry skills tests. The results revealed that virtual learning environments provided statistically significantly better conditions for seventh-grade students to enhance their conceptual understanding of the topic of the interaction of light with matter and to improve their inquiry skills.

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783 Math4U Portal - Practising Secondary School Math in Five Languages

Petr Beremlijski, Petra Vondráková

VSB-Technical University of Ostrava, Ostrava, Czech Republic

Abstract

This article introduces Math Exercises for You (Math4U), a practice portal for secondary school mathematics. It offers attractive and comprehensive learning materials for students and provides teachers with tools to prepare tests and exams. The main goal of the Math4U portal

(math4u.vsb.cz) is to enable the practice of all secondary school mathematics. The entire portal and all materials are available in English, Spanish, Czech, Polish and Slovak. In this paper, we will also focus on investigating the use of the portal by its users. We will use the Google Analytics tool for this research.

1016 Teahcers in Crisis: How They Addressed Online Chemistry Teaching During COVID-19

Ehud Aviran, Ron Blonder

Weizmann Institute of Science, Rehovot, Israel

Abstract

In an effort to continue teaching chemistry and to address the unique needs of chemistry teaching during the spread of Covid-19, teachers turned to an online system for personalized teaching and learning (PeTeL) while facing the challenges of adapting to the "new normal". This mixed-methods study aims to explore chemistry teachers' attitudes, their perceptions of students' self-efficacy, and their personal vision for teaching with technology during that time. The teachers submitted a questionnaire consisting of a 5-point Likert scale and open-ended questions. The results indicate that the teachers significantly increased their perception of students' efficacy to learn, but there was no significant change in their attitudes regarding using technology for teaching, or personalized chemistry teaching. Analysis of their answers to the open-ended questions revealed the differences between how they perceived ideal online teaching and what they actually did in their teaching. Insights for online chemistry teaching are drawn, and a theoretical tool for obtaining a better understanding of teachers' attitudes and motives in online teaching is proposed.

Parallel Session - 1.6 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: William Veal

283 Creativity in Science and Chemistry: A Cross Cultural Comparison

William Veal[1], Doras Sibanda[2]

[1]University of Charleston, SC, Charleston, SC, USA. [2]University of KwaZulu-Natal, Pietermaritzburg, South Africa

Abstract

The purpose of this study was to garner perceptions of creativity from chemistry professors from three different countries in order to determine the attributes that content specialists might have when teaching science content. There are many definitions of creativity, and the different

attributes can be found with differing emphasis in the field of science and domain of chemistry. The Five A's model of creativity and socioculturalism were used as the theoretical frameworks to develop survey questions and analyze interview data. The Nature of Science and the Nature of Chemistry, as objective Western constructs, were used to influence how creativity was compared across different cultures. The a priori themes from the literature were problem solving, process, product, genius, convergent thinking, and divergent thinking. The emergent themes differed between Western and South African content experts. Science from a Western perspective had more influence on creative thinking than the cultural aspects of the chemistry content specialists' lives. The African definition and use of creativity was found to be an amalgam of those from the West and East. An understanding of the nature of creativity from different cultures using the objective context of science and chemistry should promote the development of creativity in science and chemistry.

401 "Discovery of Archaeologists" as an Activity of Teaching the Nature of Science

Canan Tunç Şahin, Canay Pekbay

Zonguldak Bülent Ecevit University, Zonguldak, Turkey

Abstract

The aim of this study was to introduce a nature of science activity developed with an explicit-reflective approach and enable pre-service science teachers to realize the elements of the nature of science by experiencing this activity. The "Discovery of Archaeologists" activity, which includes the discovery of wall paintings found in Çatalhöyük, Konya, by archaeologists, was carried out with a group of 20 pre-service science teachers. Video recordings, observation notes, activity worksheets used in the process, and participants' opinions about the activity and the process which were obtained from the practices have been analyzed by researchers in terms of which aspects of the nature of science could be taught and how the designed activity could be evaluated. The data obtained from the application showed that the "Discovery of Archaeologists" activity is a sample activity that can be used in teaching the nature of science. "Scientific knowledge is based on evidence", "Observation and inference", "There is no single scientific method", "Scientific knowledge can change", "Creativity of a scientist", and "Effect of the social and cultural environment" have been revealed to be the elements of the nature of science emphasized in the activity.

927 Explicating the Meaning of Explicit Reflection in Nature of Science Education: A Systematic Literature Review

Lotte Boven[1], Peter Van Petegem[1], Rianne Pinxten[1], Jelle De Schrijver[1,2]

[1]University of Antwerp, Antwerp, Belgium. [2]Odisee University College, Brussels, Belgium

Abstract

For over two decades 'explicit reflection' has been a commonly used concept in the context of Nature of Science (NOS)-education. Yet, coining the meaning of this concept isn't easy. Authors and scholars use the term to refer to very distinct, if not contradictory ideas. Sometimes, authors share the meaning of explicit reflection only vaguely or not at all. Through a systematic literature review we aim to elicit the various meanings of explicit reflection. The papers eligible for the systematic review were selected following the PRISMA method. We explored five electronic databases and one science education book. Selected papers needed to focus on NOS education and explicit reflection. This resulted in 88 studies (published since the year 2000) that fit within the scope of this systematic review. Our findings show key recurring terms in the definitions of explicit reflection, terms such as 'planned for', 'deliberately drawing attention to' and 'making connections to what scientist do'. We observe a slight evolution in the meaning of ER over the last two decades: certain words are less emphasized in the definitions. We explore how the diversity in the definitions of explicit reflection in NOS education relates to the scholars' epistemological paradigmatic assumptions.

1122 Nature of Science Aspects Expressed by Students in a Hands-on Modeling Lesson About Plasma Membrane in a Biochemistry Class

Daniel Manzoni de Almeida[1], Marsilvio Gonçalves Pereira[2]

[1]UBO, Brest, Bretagne, France. [2]UFPB, João Pessoa, PB, Brazil

Abstract

Here presents an analysis of the nursing students' view of the nature of science, participants of a practical activity with the use of modeling and plasma membrane models aimed at promoting reflection on these aspects. The results show which aspects circulate among the students' ideas and which require more attention, guiding future proposals for teaching and learning activities on the nature of science.

Parallel Session - 1.7 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Shulamit Kapon

405 Investigating the Relationships Between Inquiry-Learning, Direct-Instruction, and Epistemic Cognition in Science Across 3 Countries: Evidence From PISA.

Dean Cairns

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Abstract

Epistemic cognition refers to an individual's considered beliefs about the nature of knowledge and the processes by which it is justified or developed. Epistemic cognition in science (ECS) can be developed through science learning experiences and was reported by the OECD as strongly, positively related to science achievement. This is most likely due to the pedagogic benefits of students understanding the limits, certainty, and criteria for "knowing" when learning about science. This study investigated how the learning experiences of students are related to their ECS by determining the relationships between inquiry-learning (IL), direct-instructional (DI) teaching approaches and the level of sophistication of 15-year-old students' ECS. These relationships were tested in for 34349 students across 3 countries (Singapore, UK, and the UAE), with varying levels of performance in the PISA 2015 science assessment, using multi-level regression modelling using the software package Mplus version 8.4. Preliminary findings indicate that IL has a weak or insignificant relationship with ECS for all countries whilst DL has a strong, positive relationship. However, DI moderates the IL relationship with ECS such that at higher frequencies of DI, IL is positive for students in the UK and UAE. These findings suggest that for Singapore, both increased levels of IL and DI are related to improved science performance directly. In the case of the UK and UAE, IL appears to only be an effective approach when there are also high levels of DI whilst at low levels of DI, IL is negatively related to ECS. The implications for these findings are discussed in terms of recommendations to policy and practice changes in science education, particularly in the UAE and the UK.

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548 The Role of Science Self-Efficacy and Engagement in STEM Interest

Dekant Kıran

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Abstract

The purpose of this quantitative study is to predict middle school students' interest in STEM through their self-efficacy and engagement in science classes. Motivation and engagement are two critical factors that influence students' interest in STEM subjects. However, research on the relationship between these two elements and students' STEM interest is limited. The participants of the study were 152 seventh and eighth grade middle school students. The data were collected by three measures that assess students' science self-efficacy, engagement in science class, and STEM interest. Descriptive statistics were run to depict general statistics and regression analysis was performed to reveal how science self-efficacy and dimensions of engagement contributed to STEM interest. The results indicated that four engagement dimensions, namely, agentic engagement, behavioral engagement, cognitive engagement, emotional engagement, and self-efficacy, were correlated positively with STEM interest. Students' science self-efficacy (β=.18) and their cognitive engagement (β=.35) in science classes were the only positive predictors of their interest in STEM. However, the other engagement dimensions were not found to be statistically significant predictors of STEM interest. Teachers, families, and policy makers are advised to support students to enhance their

efficacy and cognitive engagement in science classes to orient students in STEM professional pipeline. Results are discussed.

704 Developing a Taste for Science in Primary School

Per Anderhag[1], Cecilia Caiman[1], Anna Jeppsson[2], Magnus Nilsson[2], Pia Larsson[3], Per-Olof Wickman[1]

[1]Stockholm University, Stockholm, Sweden. [2]Stockholm City, Stockholm, Sweden. [3]Nacka Municipality, Nacka, Sweden

Abstract

In this study we report findings on how the development of taste for science among primary school students can be supported by fine-tuned adjustments in teaching. The concept of taste is a proxy for student interest, treating aesthetic and cognitive aspects of science learning as intertwined and as constituted in action. The study is part of a larger project in which we, teachers and researchers, collaborate in developing teaching for supporting communicative processes in the science classroom. The aim of the project is to develop didactic models for classroom communication, making them useful for teaching primary science particularly for second-language learners with non-academic backgrounds. The data for the present study come from one of school in a suburb to Stockholm, Sweden, where the participating students (year 2, ages 7-8) made an inquiry on categorization and one on fair testing. Our study demonstrates how an inquiry task can be made interesting to students by combining three relatively simple didactic models from previous research. These adjustments regard both how lessons can be designed to support students' taste and learning, and how they can be analysed to assess their effect. In our presentation, the various models used in this piece of research will be summarized as one coherent didactic model, which can be utilized by teachers to support inquiry-based learning and teaching in school.

713 Epistemic Agency and Epistemic Affect in Open Inquiry: Teacher-Research-Mentors' Perspectives

Asnat Zohar[1,2], Salih Faraj[1], Amos Cohn[3], Shulamit Kapon[1]

[1]Technion - Israel Institute of Technology, Haifa, Israel. [2]The university of Haifa, Haifa, Israel. [3]Oranim Academic College of Education, Kiryat Tivon, Israel

Abstract

This paper examines the meaning and concrete operationalizations of epistemic agency and epistemic affect in a real educational context as they emerged from an analysis of interviews with core members of a unique professional community of practice dedicated to the incorporation of authentic inquiry experiences in mainstream high school physics. The interviewees (N=14) are physics educators who have been mentoring for many years open inquiry projects in physics at the advanced high school level and/or have been involved in

attempts to institutionalize such learning experiences in mainstream schooling. The findings illustrate the deep interrelations between epistemic affect and epistemic agency, and in particular how epistemic affect facilitates enactments of epistemic agency. We highlight features of teachers' epistemic agency and epistemic affect that play a key role in fostering students' enactments of epistemic agency, and point to the main institutional and social features that enable and support these learning experiences.

Parallel Session - 1.8 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Sari Havu-Nuutinen

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127 Assessment of Creativity: Development of a Model and Teachers' Realization.

Erik Mogstad, Berit Bungum

The Norwegian University of Science and Technology, Trondheim, Norway

Abstract

Creativity is an important 21st century skill but challenging to assess. This study presents a model aimed at supporting teachers in making creativity form part of assessment, and results from the first cycle of a design-based intervention where the model was tested in four schools. The model is made in the context of science and technology teaching that combine creativity with programming and subject learning in lower secondary school. The model has two components: assessment criteria and methods for gaining insight in student processes, where the latter is based on perspectives on creativity as attributed to a process, not the product. It is developed in interplay between theoretical perspectives on creativity and results from interviews with teachers that revealed their views on challenges and opportunities in assessing creativity in the classroom. Testing was undertaken by four teachers engaged in the project. Results show that the use of assessment criteria for creativity is challenging for teachers, but that they found the methods of gaining insight into students' processes helpful. A tension is identified between applicability and value of ways of gaining insights into students' processes.

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179 Does Exemplary Inquiry Based Learning Support Understanding of Nature of Science?

Shani Zur, Tali Tal

Technion, Haifa, Israel

Abstract

Inquiry-based learning is a well-established approach in science education. A well-conducted inquiry-based learning offers students opportunities to engage with and reflect on the scientific endeavor. Thus, inquiry activities could support students' understanding of the Nature of science (NOS). However, there are evidence that inquiry is often presented in a narrow, controlled manner that does not engage students in epistemic thinking or reflect the scientific endeavor. A coherent empirical investigation is needed to determine if and to what extent NOS aspects emerge in well-implemented inquiry activities. In this study, we examined which aspects of NOS are evident in Exemplary Inquiry Learning (EIL) and what categorizes the use of NOS in EIL activities. We used the Family Resemblance Approach (FRA) as an analysis framework to examine six EIL implementations. Altogether, 157 statements related to NOS emerged from the data: 67.5% of the utterances reflected the Cognitive-epistemic aspect, and 32.5% the Social-institutional one. Scientific practices and professional activities were evident in teachers' plans of the EIL. However, most references to NOS were implicit. The teachers did not emphasize them in their initial goals but they did so in the description of the dialogue between them and their students. This study expands the knowledge of the NOS aspect that emerges while teaching inquiry. Implications for inquiry implementation are discussed.

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397 Linking Basic Ideas about Chemical Reactions

Valerie Hollwedel, Annette Marohn

Institut für Didaktik der Chemie, Universität Münster, Münster, Germany

Abstract

It is universally acknowledged that students struggle with linking the macroscopic, submicroscopic and symbolic level of the chemistry triplet while simultaneously lacking a fundamentally connected understanding of some basic concepts of chemistry. This paper proposes a design-based research approach to these challenges of chemical education by transferring the concept of basic idea from mathematics education to the teaching of chemical reactions.

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441 Primary School Students´ Perceptions of Studying STEM Subjects and Experiences of Science Capital Lessons

Sari Havu-Nuutinen, Sini Kontkanen, Sirpa Kärkkäinen, Katariina Waltzer, Ella Suortti

University of Eastern Finland, Joensuu, Finland

Abstract

The existing research has indicated the relevance of science capital in society and its connections to behavioral choices done in challenging societal questions. Science capital refers what people know and think about and towards science, how they perceive science in their life

including the use of science media, social relations, and science aspirations. The dimensions of science capital offer interesting framework to support the students' increasing engagement in science learning and science careers. The aim of our study is to clarify primary school students' perceptions, attitudes, and aspirations about science learning before and after science capital lessons and how they experienced the science capital lessons. The research questions were 1) how did students perceive studying STEM subjects? 2)how students' attitudes and aspirations towards science appeared before and after the science capital lessons? 3) how students experienced the science capital lessons? Data was collected from the pre- and post-surveys during the science capital intervention study with 4th graders in eastern part of Finland during the school year 2021-2022. Totally 97 students participated in the study. The students' awareness of science learning increased during the intervention, but their attitudes and aspirations did not change dramatically. The research results provide support for systematic teaching of science capital as students' experiences were positive.

Parallel Session - 1.9 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Peter Fairhurst

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451 The Effect of International Baccalaureate Middle Years Program (IB MYP) on the Students' Scientific Process Skills in Science Courses

Şefika Girgin

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Abstract

The purpose of this study was to reveal the effect of IB MYP on the development of the students' scientific process skills which given importance and priority in science curriculum. Science within the IB programs encourages inquiry, curiosity and ingenuity. In this manner in the MYP units, a statement of inquiry was developed according to key and related concepts and inquiry questions were used to explore the subjects. So through their inquiry, students develop specific interdisciplinary and disciplinary approaches to learning skills. In this study, students' scientific process skills were examined based on MYP science lessons for one year period. Sample of the study consisted of total 14 7th grade students who had experience on MYP from 5th grade. Evidence of scientific process skills was sought from formative and summative assessments and transcripts from classroom observations during the first unit (Transformation of Energy) and the fourth unit (Interaction in Energy). Each unit took eight weeks and while first unit implemented in the beginning of the year, fourth unit was in the end. The main purpose of education is to equip individuals with the scientific skills necessary to be curious, inquisitive, find solutions to problems, exploration, and access information. So, results of the study also represent that MYP science lessons develop students' skills in creating hypothesis, driving research questions,

determining variables, collecting and interpreting data. Scientific process skills were the themes of the study and under these themes codes were determined. Results represent that scientific process skills support a better understanding of how scientific knowledge and processes are experienced in the light of MYP science lessons which students construct meaning by designing, conducting and reflecting on scientific investigations and enables students to make informed and responsible decisions.

458 Fostering Young Children's Scientific Practices in Urban and Indigenous Areas: An Investigation of Instructional Strategies

Ching-Ting Hsin[1], Hsin-Kai Wu[2], Di Tam Luu[1], Min-Erh Wei[3]

[1]National Tsing Hua University, Hsinchu, Taiwan. [2]National Taiwan Normal University, Taipei, Taiwan. [3]Jin-Cheng Preschool, Kinmen County, Taiwan

Abstract

The purpose of this study was to investigate how kindergarten teachers in urban and Indigenous areas used instructional strategies to promote their students' scientific practices. Five teachers from four kindergartens in northern Taiwan (two in cities and two in Indigenous villages) implemented an early science learning module. The teachers' average age and years of teaching were 37.4 and 15.4. 78 children (38 boys and 40 girls) participated in the study, 53 living in the cities and 25 in the Indigenous villages. Their average age was 5 years and 8 months. We collected video recordings of the lessons (44 hours and 4 minutes and 25 hours and 54 minutes in each area respectively). Qualitative data analysis techniques were used to develop coding schemes of the instructional strategies and children's scientific practices. Chi-square tests were performed to compare the differences in two areas. The analysis of the levels of children's scientific practices revealed that in both areas, teachers' use of instructional strategies were effective. Furthermore, teachers in the Indigenous area used more strategies to support children's development of language skills and scientific practices, including probing, using diagrams to synthesize data, comparing and contrasting, and demonstrating by teachers. Urban teachers tended to enact strategies related to the management of a large class, including reconciling disputes, using images to help children focus, providing direct instructions, and using simple question-answer exchanges. This study provided insight into how to effectively implement an early science intervention that can engage children in scientific practices and meet the needs of children from diverse backgrounds.

463 How to Ensure Quality of Teaching and Learning Sequences? an Approach From the DBR Paradigm

Èlia Tena, Digna Couso

UAB, Barcelona, Spain

Abstract

Despite the importance of quality of Teaching-Learning Sequences (TLS) in the design-based research (DBR) paradigm, how to do its evaluation it is not clear in the literature (van den Akker, 2013). In addition, most published research shows a lack of connection between the actual evaluation of the TLS and the series of changes done to improve it (Guisasola et al., 2021). In an attempt to contribute to clarify this, in our research we have revised some of the most relevant literature in DBR to identify: a) the essential elements and crucial stages of the process of designing a TLS that is both research-based and evidence-based; and b) the evaluation criteria to analyse this sequence from a quality perspective. As a result, we propose a new operative theoretical and methodological framework to evaluate and improve iteratively the quality of TLSs in the DBR paradigm. This framework is focused on three specific quality dimension (validity, usefulness, and reliability) and seven evaluation criteria. The application of the proposed framework in a real context to empirically evaluate and improve different prototypes of a TLS on the topic of air pollution highlights the chronological, sequential, and accumulative nature of this evaluation process.

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477 Developing Science Teachers' Pedagogical Content Knowledge and Maximising Students' Progression With Open-Access Research-Informed Teaching Resources, on a Very Large Scale

Peter Fairhurst, Alistair Moore, Helen Harden, Judith Bennett, Simon Carson

University of York, York, North Yorkshire, United Kingdom

Abstract

"Teachers are unlikely to take up ideas from research if such ideas are presented only as general principles … what they need is a variety of living examples of implementation." This observation was made by Paul Black and Dylan Wiliam in 1998. Since then, calls for 'evidence-informed practice' have persisted. However, comparatively few 'living examples' have been developed to support day-to-day science teaching. This paper discusses the design, development and impact of a very large-scale project, which aims to bridge the gap between principles emerging from research and the resources and support that are available for teachers. The project has developed a structure, rationale and resources that draw on research evidence available in a number of key areas pertinent to science education: curriculum structure and the sequencing of science ideas, how to teach difficult ideas in science, the use of assessment to support learning, gathering evidence of effective learning and progression, and engaging teachers in utilising research evidence in their planning, teaching and reflection in order to develop pedagogical content knowledge. The backbone of the project is a science learning framework that draws systematically on the research evidence on how children learn science. This provides a map of the key concepts in the main school science topics, sequenced in a logical order with reference to research. The framework is supported by a range of research-informed educative teaching resources, including, for each key concept, learning progressions, diagnostic questions, and corresponding response activities. In this presentation

we will draw on several case studies to provide evidence for the efficacy of our materials in engaging practicing science teachers with research evidence to develop teaching practice. We will also outline the wide-ranging impact of this work more broadly, for example in influencing aspects of science teacher training across England and Wales.

Parallel Session - 1.10 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Isabel María Cruz-Lorite

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644 The Nature of Facilitation in a POGIL-Based Chemistry Class

Zübeyde Demet Kirbulut Güneş[1], Amy Joyce Phelps[2], Shaghayegh Fateh[2], Karolin Abouelyamin[2], Joshua W. Reid[3], Gregory T. Rushton[2]

[1]Gazi University, Ankara, Turkey. [2]Middle Tennessee State University, Murfreesboro, Tennessee, USA. [3]Texas Tech University, Lubbock, Texas, USA

Abstract

Several studies have highlighted the critical role of classroom talk in the scientific meaning making process by students. The purpose of this study was to investigate how instructors engage their students in science classroom talk. Specifically, we focused on the communicative approaches the instructor uses while facilitating small-group discussions in a POGIL-based chemistry class and the factors affecting the instructor's implementation of facilitation. This study was conducted in a General Chemistry class with an enrollment of 24 students at a large, teaching-focused university in the Southeastern US. This course utilized a POGIL approach and students worked in small groups of 4 or 5 to complete the POGIL activities. In this study, two student groups were observed across twelve class periods of 90 minutes each, which included 59 facilitation episodes in total. The data were analyzed considering every facilitation period for each question. Facilitation periods were identified as the instructor's interaction with small groups while they were working on POGIL activities. To analyze the instructor facilitation, we used Mortimer and Scott's (2003) analytical framework for the communicative approach. Semi-structured interview with the instructor was conducted across a one-hour session to determine the factors that affected the instructor's facilitation. The results showed that the instructor adopted interactive/authoritative (n = 29) or non-interactive/authoritative (n = 30) communicative approaches across twelve classes. There were no observed instances of either interactive/dialogic or non-interactive dialogic approaches in the sample of classes collected for this study. The instructor indicated that there were factors such as time constraints, curriculum, and students' characteristics that affected her facilitation.

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768 Developing a Question-Answer Based Model of Argumentation: Addressing Inadequacies of Toulmin and Other Models

Gurinder Singh[1], Karen Haydock[2]

[1]Azim Premji University, Bangalore, Karnataka, India. [2]Homi Bhabha Centre for Science Education, Mumbai, Maharashtra, India

Abstract

In studying and analysing student argumentation, science education researchers have often used the original or modified forms of Toulmin models. However, some researchers have questioned the adequacy of these models, which largely borrow ideas of syllogistic logic, in analysing and evaluating argumentation in a real life discourse. We found that real life discourse is quite complex and requires an analysis that addresses functional, social, and affective aspects. Reducing such a discourse to just claims, evidence, justifications, etc., as is done in Toulmin-type analyses, does not adequately address the potential understanding of the discourse. Also in real life situations, distinguishing different kinds of statements from one another (say data and warrants) is very challenging. In particular, we found that there is a need to explicitly study questioning in understanding argumentation. Furthermore, Toulmin models fail to address issues of gender, class and authority present in most real life discourses. In this paper we discuss a question-answer model of argumentation to address inadequacies of Toulmin's model. By analysing some episodes of middle school students' talk, we provide examples of how such a model could be useful in analysing and understanding student argumentation.

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364 Understanding High School Students' Scientific Argumentation Competence (SAC) From Their Perspective

Jinglu Zhang

Nanjing Normal University, Nanjing, China

Abstract

Scientific argumentation (SA) is an important practice in science teaching and learning, in which students are provided with opportunities to develop scientific literacy by constructing and evaluating arguments formed by themselves and others. It has been widely found that students' engagement in scientific argumentation needs to be promoted and deliberate instructions are required. There has, however, been little study exploring students' experiences in engaging in scientific argumentation. Therefore, this article explores students' experience of participating in an assessment for SA. Specifically, SAC is decomposed into three components by referring to a wide range of literature and Bloom's Taxonomy: Identification of SA, Evaluation of SA and Production of SA. Each component is composed of three or four elements according to Toulmin's argument model. As part of an iterative process of understanding students' SA engagement, a total of 30 students were interviewed after taking two large-scale assessments. All the interview data were collected using audio calls, and transcribed. The author analysed all

the interview transcripts using reflexive thematic analysis. Three themes are constructed to capture the students' experiences: Students' perceptions about SA, Students benefit from taking the SAC assessment, and Challenges of engaging in SA. Each theme involves two sub-themes, namely, Existing awareness of SA transferred from previous experience, Positive attitude on SA and the assessment; Pedagogical function of the assessment, Introspections through the assessment; Lack of opportunities to engage in SA, Difficulties of engaging in SA.

131 Application of Felton and Kuhn's Framework for Analysing Argumentative Skills During a Role Play

Isabel María Cruz-Lorite[1], Maria Evagorou[2], Daniel Cebrián-Robles[1], Ángel Blanco-López[1]

[1]University of Malaga, Málaga, Andalucía, Spain. [2]University of Nicosia, Nicosia, Nicosia, Cyprus

Abstract

Argumentation has become important for understanding how people reason and make decisions about socioscientific issues. One challenge of science education is promoting argumentation practices in science classrooms and improving preservice teachers' argumentation skills, which is essential to reinforce their future teaching practices. In this paper, we analyse the preservice primary teachers' discursive processes when participating in a role play about nuclear power to identify their main limitations in argumentation practice. 28 preservice primary teachers from the University of Malaga participated in this study during the 2018/19 academic year. For data analysis, an adaptation of Felton and Kuhn's framework was applied. The results show that role play as a teaching strategy has favoured the use of counterarguments and countercritics, although, at the same time, there is also a lack of use of dialogic resources to question the arguments of others.

Parallel Session - 1.11 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Senay Purzer

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296 Integrating Science into High School Interdisciplinary Aesthetic Education Curriculum and Teaching

Shian-Jang Wang[1], Huei Lee[2]

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Abstract

STEM or STEAM, which combines the learning of arts, is a well-known interdisciplinary practice in science education. However, these courses are primarily based on science, where the discipline of arts is only marginally represented in the educational curriculum in Taiwan.

Currently, it is observed that students in rural areas have insufficient aesthetic experience and have low achievement and motivation in science learning. Therefore, this study aimed to develop interdisciplinary aesthetic courses that include scientific concepts and investigate student's performance in this curriculum. This study not only adopted the qualitative approach to conduct and collect information from classroom observation, student interview, and teachers' reflective notes of a class during a semester in a rural vocational high school taught by the researcher, but also used some quantitative tools such as Rubrics' scale and evaluation of students' attitudes toward science in thematic analysis to assess their learning, to serve as an interpretative reference in the future. It was found that integrate science into the curriculum of aesthetic education was helpful for students' aesthetic learning, even though there was less significant improvement in their attitudes and learning of science, despite that there was a slight incline of interest in science shown by the students. It was noted that the interdisciplinary aesthetic experience and scientific courses could motivate the interest of learning in these students of rural areas, for which the courses would broaden both the depth and breadth of their aesthetic learning.

1290 Learning and Agency Through Design Negotiation: The Honeycomb of Engineering

Senay Purzer

Purdue University, West Lafayette, IN, USA

Abstract

The practice of negotiation in engineering can be considered as analogous to argumentation in science. Engineering is creating, monitoring, managing, and improving technological systems through the careful negotiation of risks and benefits. The Honeycomb of Engineering framework describes engineering with an epistemological lens first but then articulate its pedagogical translations. Engineering encompasses different types of inquiries: user-centered design, design-build-test, engineering optimization, engineering science, engineering analysis, reverse engineering. In addition, engineering design is a flexible and adoptable vehicle that can be used to guide different types of engineering inquiries, with the negotiation of risk and benefits at the center of this process. My goal is to broaden the view of engineering education from simply being defined as a hands-on approach and uncover the underestimated potential of engineering for education. Engineering education can promote a diverse range of outcomes such as purposeful utilization of students' cultural heritage and assets, develop reasoning necessary for learning but also sustainable and ethically-conscientious design; and build students' agency and decision-making skills.

1260 Promoting Arab Teachers Towards Integrating Robotics-Enabled STEM Lessons

Nayif Awad[1], Esmael Salman[2], Amtiaz Fattum[2]

[1]Sakhnin Academic College for Teacher Education, Israel, Israel. [2]The Arab academic college for education - Haifa, Haifa, Israel

Abstract

Cultural and socioeconomic issues play a major role in shaping the educational outcomes of state educational systems (Broer, 2019). In Israel, these factors relate to educational inequity expressed by differences in student achievements in science and technology between Palestinian Arab (minority) and Jewish (majority) populations based on international measurement tests (Blass, 2020). To bridge this gap, it became imperative to empower Arab teachers and students in STEM education. However, most Arab teachers still lack the required knowledge in STEM subjects. Since robotics is a well-known platform for advancing integrative STEM and student-centered learning of scientific-technological concepts, 88 in-service teachers studying for a second degree in two Arab teacher colleges took a STEM course. The course introduced educational robotics and its use in learning basic mathematical and physical principles. Later, seven teachers (out of 88) applied activities with their students in mathematics, physics, and programming lessons. Data collection tools included a questionnaire (Barak & Assal, 2018) examining participants' motivation and interest to learn, acquire problem-solving skills, and conceptual knowledge, and semi-structured interviews held with seven teachers. Questionnaire findings showed that in-service teachers found robotics useful for engaging learners in problem-solving and facilitating meaningful learning of scientific-technological concepts. The participants expressed high motivation and interest in applying robotics-enabled STEM lessons in their classes in the future. Moreover, the interviewed teachers asserted that robotics brought enjoyment to their classes, helped them illustrate theoretical concepts, and stimulated spontaneous collaborative learning without gender distinction. However, they complained that integrating robotics is time-consuming and could hinder the curriculum progress. To conclude, teachers evaluated robotics as a useful platform having the potential to emphasize STEM learning and strengthen students' affective and cognitive dimensions. More training and research are needed to leverage teachers' development in STEM among underrepresented populations and examine its effectiveness in narrowing gaps in academic achievements.

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366 Interdisciplinary in Science and Mathematics through Reasoning and Visualization

Janelle McFeetors, Josh Markle, Mijung Kim

University of Alberta, Edmonton, AB, Canada

Abstract

Despite efforts to integrate science and mathematics learning in elementary school through carefully designed activities, students' cognitive and communicative tools remain relatively unexplored as a possible place of interdisciplinarity. We believe reasoning and visualization are productive co-curricular processes that lead to meaningful, coherent learning. We conducted a document analysis of current curricular changes in a Canadian province, which subsequently informed prototype tasks. Data included four curriculum documents and field notes from professional learning sessions with elementary science and mathematics teachers. We found curricula provide a framing for enactment of processes, despite an absence of formal conceptualizations of reasoning and visualization. Grounded in curricular expressions, our prototype tasks elicited reasoning and visualizing, through which teachers' perceptions of the boundaries of the disciplines intersected and blurred as they noticed the importance of the processes on learning and problem solving.

Parallel Session - 1.12 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Meltem Irmak

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129 Meat Consumption in the Food Habits of Pre-Service Teachers: Implications for an Approach to the Issue in Training Courses

António Almeida[1], Isilda Rodrigues[2], Rafael Sumozas[3]

[1]Instituto Politécnico de Lisboa / CICS.NOVA, Universidade Nova de Lisboa, Lisbon, Portugal. [2]Departamento de Educação e Psicologia, UTAD; CIIE, Universidade do Porto, Portugal, Vila Real, Portugal. [3]Facultad de Educación de Ciudad Real, Universidad de Castilla-La Mancha, Ciudad Real, Spain

Abstract

The present study aimed to identify the meat consumption habits of 197 pre-service teachers, mostly female, from two higher education institutions, one located in an urban area and the other in a rural area. A questionnaire was designed to determine the frequency of weekly consumption of various types of food, the more frequent diet and the food chosen when eating out. Meat consumption is very frequent among students of both institutions, with the majority following an omnivorous diet, without any restrictions. These options were even higher among participants from the rural area. The results will be the starting point for an in-depth approach to the impact of meat consumption in terms of i) human health, ii) environment iii) and animal welfare, seeking to fill a gap in the students' training. It is hoped that this training will contribute to a change in some personal food habits and to a better understanding of the importance of approaching this issue in their professional future in the three dimensions cited above.

935 A Study on Common Ability of STEM Human Resources Community: Focus on Higher Education Students in Japan and the United States of America

Tomotaka Kuroda

Okayama University of Science, Okayama, Japan. Graduate School of Science and Technology, Research Division, Shizuoka University, Shizuoka, Shizuoka, Japan. Tama University, Tama, Tokyo, Japan

Abstract

In Japan, as in other countries, expectations from STEM (Science, Technology, Engineering and Math) human resources are rising, and, accordingly, significant reforms of the educational environment are underway. In order to develop human resources, it is important to examine competencies. This study examines competencies corresponding to both, the culture of the STEM human resource community, and the cultural influence of the country of residence. Specifically, a questionnaire was administered to students taking first-year university courses in Japan and America. The results demonstrated that, of the 21 assumed competencies, six showed no significant differences; it also suggested that "high expertise and the ability to use creativity to solve problems and execute plans according to specific situations" are among the required competencies. For future study, it will be necessary to gather additional data, and conduct further research with questionnaire respondents, via interviews.

988 Opinions of Young People From São Paulo (Brazil) About Science and Technology

Paulo Sano[1], Renata Allito[1], Leonardo Araújo[1], Nelio Bizzo[1,2], Fernanda Franzolin[3], Paulo Sérgio Garcia[4], Paulo Monteiro[5], Isabela Nogueira[1], Wallace Santos[1], Rebeca Viana[1]

[1]USP, São Paulo, São Paulo, Brazil. [2]UNIFESP, Diadema, São Paulo, Brazil. [3]UFABC, Santo André, São Paulo, Brazil. [4]USCS, São Caetano, São Paulo, Brazil. [5]IBu, São Paulo, São Paulo, Brazil

Abstract

This survey is part of The Relevance of Science Education Project (ROSE), which has had a first round almost 20 years ago comprising samples from more than 20 countries with high school students aged 14-16 seeking to understand young people's attitudes and interests about Science and Technology. Now a second data collection instrument was created based on the previous one. A total of 111 items in paper-pencil forms were presented to 676 students in the second half of 2022. Items consisted of statements about science and technology, designed in a Likert-type scale, with four options, and no neutral point. Students' answers are optimistic about the role of science for their future lives as well as for the country considering their agreement with statements related to the improvement of health care, vaccines etc. However, this optimism retains a certain critical approach, as they strongly disagree that science will contribute to social justice. They also strongly disagree that we should always trust what

scientists have to say, indicating a sharp perception of the links between the scientific enterprises and economic interests. More analyses are under way and data collection will continue along 2023, trying to reach other regions of the country.

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664 Sources of Information That STEM Students Used While Deciding on Socioscientific Issues

Meltem Irmak[1], Büşra Tuncay Yüksel[2]

[1]Gazi University, Ankara, Turkey. [2]Giresun University, Giresun, Turkey

Abstract

Undergraduate students who are pursuing education in STEM departments are expected to be conscious citizens who can make informed decisions about socioscientific issues (SSI) in the future. STEM students might use different information sources like media, experts, scientific books, or articles related to the topics they make decisions about. In this study, patterns of STEM students' positions and consulted information sources in decision-making regarding antibiotics use, genetically modified food consumption and construction of nuclear power plants in Türkiye were investigated. Data were collected with open-ended questions and analyzed through inductive analysis. Results showed that the most frequently used information source was media. STEM students used media, especially in the topics they did not have school-based scientific knowledge; however, they also used media as a source of information while making decisions on the topics related to their majors. This indicates the need to prepare STEM students with the necessary scientific knowledge and with a high level of media literacy to raise them as responsible citizens.

Parallel Session - 1.13 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Soykan Sandıkçıoğlu

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353 Exploring Narratives as a Tool for Imagining the Future and Fostering Agency Toward Sustainability

Giulia Tasquier[1], Alfredo Jornet[2], Hannah Rokenes[3], Erik Knain[3]

[1]University of Bologna, Bologna, Italy. [2]University of Girona, Girona, Spain. [3]University of Oslo, Oslo, Norway

Abstract

We are facing changes of epochal significance and despite the growing attention from many corners, science at school still seems to fail in being supportive for students' making sense of

these demanding socio-scientific questions. In the context of such complex problems as today's sustainability and climate change challenges, narratives become a primary and crucial means for integrating scientific knowledge relevant to science, authentic inquiry and critical thinking skills needed to pursue solutions drawing from science, and the goal-oriented, affective and active engagement in actual action. Thanks to micro-narratives, the young can have the opportunity to figure out who they are and envision plausible futures for themselves and their surroundings through making use of cultural resources in social relationships with the people who take part in these worlds. However, to what extent narratives can also provide insights into the current attitudes of young people about their sense of agency in relation to climate change and sustainability challenges? This study aims to answer this question by analysing students' narratives collected through a SenseMaker questionnaire based on sustainability stories.

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522 Binding the Sustainable Development and the Curriculum: The Effect of a Training for Pre-Service Physics Teachers

Hasan Şahin Kızılcık[1], Müge Aygün[2], Esin Şahin[3], Volkan Damlı[1], Nuray Önder-Çelikkanlı[1], Osman Türk[4]

[1]Gazi University, Ankara, Turkey. [2]Giresun University, Giresun, Turkey. [3]Çanakkale Onsekiz Mart University, Çanakkale, Turkey. [4]Gazi University Foundation Private Schools, Ankara, Turkey

Abstract

This study aims to examine the effect of sustainable development (SD) training on pre-service physics teachers' binding SD and secondary education physics curriculum. The online training was given to 26 pre-service teachers by 8 trainers for 5 days with the support of TÜBİTAK 2237-A Scientific Activities Support Program. The content of the training consists of SD goals, applications intended for the goals, and how to teach physics with different education methods intended for SD goals. Before and after the training, the participants were asked to select the units they thought were related to SD in the secondary education physics curriculum of Türkiye. The data were analysed both based on grades in the curriculum and the units. As a result, there are notable increases in the number of grades bound and, in the units, bound the exception. In general, it was determined that the participants started to think about SD in a wider context after the training and made more bound.

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657 Self-Evaluating the Networks of Schools for Sustainability in Catalonia Using a Collaborative Evaluation Tool

Arnau Amat, Chadia Rammou, Laura Martín

Universitat de Vic - Universitat Central de Catalunya, Vic, Spain

Abstract

This study reports on a project commissioned by the Catalan Government with the goal of designing an evaluation tool for the Network of Schools for Sustainability in Catalonia, which

comprises 18 networks with more than 1400 schools. The tool was constructed using the tenets of the constructivist evaluation with the support of the environmental officials in charge of these networks. A broad range of instruments were used to collect data. The first outcome of the project is an evaluation tool composed of 25 criteria divided into 5 dimensions. The second one is the results of the self-evaluation conducted by the officials of the NSSC.

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155 Attitudes of Pre-service Science Teachers Towards Biodiversity

Soykan Sandıkçıoğlu

Middle East Technical University, Ankara, Turkey

Abstract

The research has been designed to determine the attitudes of pre-service science teachers toward biodiversity. A quantitative research method that was a descriptive survey study, was used. 64 Pre-services science teachers were selected for the study at a university in Ankara. ''Attitudes Towards Biodiversity'' questionnaire was used to identify pre-service science teachers toward biodiversity. Biodiversity is a critical and important term for our society. However, biodiversity is under threat. Anthropogenic actives are originating from human activities such as pollution, deforestation, habitat destruction, excessive usage of natural sources, etc. significantly declining biodiversity. Therefore, people conserve and protect biodiversity. At this point, teachers play a critical role in our society. Teachers directly contribute to the shaping of future society, so teacher education is important for public awareness and quality of education. Also, studies show that environmental action and behaviors are linked with environmental attitudes. Therefore, investigation and integration of these concepts can be affected the personal values of the people and can help to construct a better awareness of biodiversity. For this reason, determining pre-service science teacher attitudes towards biodiversity can help develop educational programs and increase awareness about biodiversity concepts. To examine this in-depth, this study aims to examine the attitudes of pre-service science teachers towards biodiversity.

Parallel Session - 1.14 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Merav Siani

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4 Preservice Science Teachers' Performances on a Test of Engineering Design Processes in the Sultanate of Oman

Mohamed Ali Shahat, Sulaiman M. Al-Balushi, Moammed Al-Amri

Sultan Qaboos University, Muscat, Oman

Abstract

A Fair Test to Measure Engineering Design Ability (FTMEDA) was developed and utilised for measuring preservice science teachers' proficiency regarding engineering design processes. A descriptive approach was chosen for the study together with quantitative data collection. A sample of 70 preservice science teachers in two programmes at Sultan Qaboos University (SQU) participated voluntarily. The two programmes included in the study were the Bachelor of Science (BSc, n = 31) and the Teacher Qualification Diploma (TQD, n = 39). The results showed that student teachers were low and moderate in their performance on an engineering design processes test. Furthermore, the BSc programme preservice teachers were more proficient in 'identifying the problem', but TQD programme preservice teachers were more competent in 'possible solutions'. Regarding gender, female participants had significantly higher performance on the engineering design processes test than male participants. Contributions to research and potential for the findings to improve STEM education in Oman are discussed.

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47 The Knowledge We Value: Examining How Theoretical Stance Impacts the Framing of Research on Preservice Science Teachers From Deficit and Asset Perspectives

Ron Gray[1], David Stroupe[2], Scott McDonald[3]

[1]Northern Arizona University, Flagstaff, AZ, USA. [2]Michigan State University, East Lansing, MI, USA. [3]Pennsylvania State University, University Park, PA, USA

Abstract

Here we explore how scholars have framed studies of preservice science teacher (PST) knowledge and learning over the past decade. We examined relevant studies between 2008 and 2018, coding them by theoretical perspective (cognitive or sociocultural), knowledge perspective (deficit or asset), and teaching level (elementary, secondary, or both) of the PSTs in the study. We found patterns between knowledge and theoretical perspective use, perspective use over time, and differences between studies of elementary and secondary level PSTs. We also found the emergence of a critical studies category of PST knowledge. We conclude with a proposed model of theoretical and knowledge perspectives as seen in the reviewed studies as well as further questions for the field.

1036 Analysis, From the Self Study Perspective, of the Teaching Practice of a Science Teacher Trainer During Two Subjets That Promote the Formulation of Good Questions in Preservice Science Teachers

Alejandra Rojas

Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile. Universidad de O´higgins, Rancagua, Chile

Abstract

The Initial Teacher Training and Scientific Education have more and more challenges since the current school contexts are highly complex, for which the understanding of the teaching of teacher trainers and the promotion of the development of competences by trainee teachers is key. This presentation is a communication of some of the findings obtained in a doctoral research that aims to investigate, based on the Self Study methodology, the understanding of my teaching practices as a science teacher trainer, in the subjects of Teaching and Learning of Natural Sciences during fourth and fifth semesters of the career of Elementary Teaching of a Chilean state university, with focus on the development of the ability to ask good questions. This research is part of the qualitative approach, from an interpretive and transformative perspective, and is longitudinal in nature. It includes the participation of eight preservice science teachers, the main researcher, and another teacher trainer who will have the role of critical friend. Four research phases are proposed, in which data will be collected with various techniques and instruments typical of the qualitative tradition, such as video recordings, research diaries, evidence of teacher training learning, among other sources. By the time this work is presented, the results of one of the specific objectives will be presented, which deals with the description of learning about teaching to formulate good questions that the researcher develops as a science teacher trainer.

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114 Possible Connections between Knowledge and Acceptance of Evolution amongst Jewish Religious Preservice Science Teachers Who Learned About Human Evolution

Merav Siani[1,2], Anat Yarden[1]

[1]Weizmann Institute of Science, Rehovot, Israel. [2]Herzog College, Alon Shvut, Israel

Abstract

Evolution is a fundamental part of biology and thus it is essential that biology preservice teachers understand and accept it. The relationship between knowledge and acceptance of evolution, and specifically human evolution, has not been fully investigated in Israel. We sought to learn about that relationship amongst Israeli Jewish religious preservice science teachers. Twenty-three religious preservice teachers completed an acceptance questionnaire (I-SEA) before and after participating in a human evolution activity. In addition, eleven of them were interviewed regarding their knowledge of evolution and four were interviewed regarding their acceptance of evolution a few months after participating in the activity. Our main findings were that the relationship between knowledge and acceptance of evolution was not always one-on-one. The preservice teachers whose evolution knowledge is high and have firm religious faith accept the theory of evolution and are willing and eager to teach it. In addition, preservice teachers might have made a shift in their understanding of human evolution and thus accepted human evolution more due to the activity. More teacher training and exposure to evolution content and pedagogy are needed so that when preservice teachers will become in-service teachers they will teach evolution without hesitance.

Parallel Session - 1.15 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Lindsay Hetherington

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313 The Impact of a Neuropedagogy-based COVID-19 Unit on Chemistry Students' Knowledge, Emotions, and Behavior Change

Shelley Rap[1], Debora Marchak[1], Moran Bodas[2], Ron Blonder[1]

[1]Weizmann Institute of Science, Rehovot, Israel. [2]Tel-Aviv University, Tel-Aviv, Israel

Abstract

This study aimed to investigate the impact that knowledge acquired in school might have on student behavior during the COVID-19 pandemic. We developed a teaching unit designed to actively engage adolescent students in learning relevant content in the fields of nano-chemistry and public health in a multidisciplinary manner. The unit was developed by considering the neuro-pedagogical principles that were shown to support memory and learning. Our main question was: How does the COVID-19 unit affect chemistry students' knowledge, emotions, and behavior regarding COVID-19 issues, especially wearing masks? Six students who took part in the unit voluntarily participated in a half-hour structured interview that was analyzed using a coding and categorization approach. The results indicate that the COVID-19 unit might have had a considerable impact on the students at the emotional, cognitive, and behavioral levels. Our findings suggest that linking scientific content to real-world issues by employing active learning strategies and strong visual literacy skills may have a positive impact on students' behavior. Furthermore, one of the implications of this study for science education may be that this approach could be applied to foster scientifically literate citizens who can make informed decisions and act accordingly.

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627 Social Technology as a Tool for Health Education Among Waste Pickers in Estrutural City

Greice Kelly Menezes Martins[1], Dayani Galato[2], Vanessa Resende Nogueira Cruvinel[2]

[1]Instituto Federal de Brasilia - Campus Estrutural, Brasilia, DF, Brazil. [2]Universidade de Brasília - Faculdade de Ceilândia, Brasilia, DF, Brazil

Abstract

Waste pickers provide essential environmental services. However they are exposed to high occupational health risks. This work aims to develop a Social Technology (ST) for health education focusing on respiratory training among waste pickers in Brasília, Brazil. The starting point was the knowledge and experience about waste and health accumulated by them. A total of 466 waste pickers were trained during four weeks about key principles of respiratory

protection. The waste pickers were involved in all steps of the training. Thus, it is expected the learning will become more effective and lasting.

1128 Material-Dialogic Learning in Ocean Literacy Education: The Ocean Connections Project

Lindsay Hetherington

University of Exeter, Exeter, Devon, United Kingdom

Abstract

The EU-Erasmus project 'Ocean Connections' project aimed to develop approaches to teaching Ocean Literacy through combining key ideas and practices from research streams in creative pedagogies and in the use of digital technologies (AR and VR). The project identified some core educative principles derived from the research literature which were then explored in practice within 6 pilot projects, 2 each in England, Spain and Denmark. At the heart of the Ocean Connections project is a material-dialogic theoretical perspective (Hetherington et al, 2019) that draws on new materialist theory to understand learning about the Ocean as a relational, emergent process. I present this theoretical framework and our rationale for its use. I then outline the pilot projects and how we collected data about the learning taking place through mixed methods, including photography, observation, interviews and questionnaires. Findings from our analysis shows that some key practices such as modelling, and student-led learning/production of and with technology can aid the enactment of a combination of creative and digital approaches for teaching ocean literacy. It also showed the potentially important role of creative pedagogies in fostering ethical, activist dimensions of ocean literacy. In presenting these findings, I particularly focus on and highlight the 'material-dialogic' nature of the learning that took place: how the interplay and intra-action of materials and language was apparent in particular ways; the role of creative pedagogies; and the specific interplay of the VR and other digital tools as material learning apparatus.

Parallel Session - 1.16 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Selvet Ece Genek

773 Identifying the Aims of Science Shows

Ruadh Duggan[1,2], Anja Kranjc Horvat[2], Sascha Schmeling[2], Wouter van Joolingen[1]

[1]Utrecht University, Utrecht, Netherlands. [2]CERN, Meyrin, Switzerland

Abstract

Science shows are widely used in informal learning contexts, such as science centres, as an excellent way to communicate science. The available research suggests that science shows can lead to many positive cognitive and affective outcomes, including increasing knowledge of a topic, helping to create positive attitudes towards science, and entertaining audiences. But do these outcomes achieve the desired aims? To properly evaluate science shows, it is necessary to first identify their aims. This year, a large organisation for scientific research will be opening a new education and outreach facility; therefore, now is the perfect time to establish the aims of the science shows that will be presented. Here, the views of participants from two expert groups are examined in relation to the aims of science shows in general, and more specifically those presented within the context of this new education and outreach facility. Preliminary results suggest that affective aims, such as entertainment, creating a sense of awe, and curiosity, are considered to be more important than cognitive aims, such as learning. The full findings and potential implications will be presented at the conference. This study will pave the way for future evaluation of science shows, both at this facility and in other contexts.

1252 Spoiler Alert! Portrayal of the Climate Crisis and Human Response in Blockbuster Movies: A Thematic Analysis

Eirini Chatzara[1], Apostolia Galani[1], George Arhonditsis[2]

[1]National and Kapodistrian University of Athens, Athens, Greece. [2]University of Toronto, Toronto, Canada

Abstract

Climate change is commonly used as a background or a prominent topic in science fiction and disaster blockbusters. It is typically portrayed in these films as a catastrophic event triggered by human activity with devastating consequences. Since movies play an important role in informal science education, these blockbusters can not only raise awareness but also lead to uncertainty or skepticism regarding climate change. In this study, we take a critical look at how climate change is portrayed in films by conducting a thematic analysis of ten blockbusters in terms of the effects of climate change depicted, the human response to it, the timeline of climate-related events depicted, and the emotions evoked. From our analysis, the climate change implications these movies depict include resource shortages, extreme weather occurrences, starting a new Ice Age, rising sea levels, and extra-terrestrial threats. As per human response, in the majority of the movies, the problem is resolved with an "easy fix" or results in society's collapse. Finally, in most of the movies, the climate-related events unfold in a matter of days, while the dominant feeling is fear. The upshot of these findings is that they emphasize the need for a) making blockbuster climate change portrayals more accurate and b) discovering educational strategies to make audiences more critical viewers.

1097 Student Teachers' Views on the Use of Virtual Out-of-School Learning in Science Teaching

Tugba Yuksel

Recep Tayyip Erdoğan University, Rize, Turkey

Abstract

Virtual Out-of-School Learning (VOSL) is an innovative approach that leverages technology to provide students with access to education outside of the traditional classroom setting. This approach can help students build on their existing knowledge, expand their skills and connect with peers, while also offering teachers the opportunity to learn new pedagogical methods and best practices in teaching. The vOOSL environment provides an interactive and engaging platform where students and teachers can collaborate, share resources, and participate in real-time discussions, simulations, and other educational activities. In this paper, we examine what student teachers think about the benefits and challenges of implementing vOOSL in their science courses before and after they engaged with vOOSL activities in their undergraduate OOSL course. The result shows that A few STs believed that vOOSL would not be as efficient as conventional OOSL. However, they had a shift of mind after participating in the vOOSL activities and seeing how they may be related to the results.

1067 Science Education Graduate Students' Views on the Relationship Between Cultural Variables and Scientific Creativity.

Selvet Ece Genek, Lin Ding

The Ohio State University, Columbus, OH, USA

Abstract

In today's world, it has become quite easy for individuals to acquire knowledge, but it is important to transform this knowledge into new scientific knowledge and products with creative and innovative ideas. Studies show that cultural environments and variables impact scientific creativity, and the role of science teachers in the classroom is essential to nurturing them. In the rapid transformation of science classes into multicultural science classes recently, the importance of science teachers and students' cultural variables has also been emphasized. In this context, the theoretical framework of the study was determined as Culturally Responsive Science Teaching (CRST). The study aims to understand international science education graduate students' views between cultural variables and scientific creativity. The methodology of the study was determined as a naturalistic research method. The data were collected with an interview form consisting of open-ended questions developed by the researchers from six international science education doctoral students in the United States. Within the scope of the interview form, the participants were asked about their cultural variables and their thoughts on scientific creativity in science education. The data analysis process of the study is continuing, and the results will be presented.

Parallel Session - 1.17 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Jan Roland Schulze

871 The Impact of Living Lab School Projects on Students' Intrinsic Motivation, Self-Efficacy and Civic Engagement

Marilena Savva, Marios Papaevripidou, Zacharias Zacharia, Yvoni Pavlou, Georgia Kouti

University of Cyprus, Nicosia, Cyprus

Abstract

This proposal focuses on open schooling projects and Living Lab methodology applications related to science learning, while encouraging schools to promote community well-being in cooperation with stakeholders. Specifically, this study examines the types of projects students employed when engaged in open schooling projects and the Living Lab methodology, by investigating how the type of prototype and stakeholder support influence students' degree of development in terms of their self-efficacy, intrinsic motivation, and civic engagement to participate in innovation communities. Six countries (Croatia, Cyprus, France, Greece, Portugal, and Spain) representing diverse schools participated in this analysis. Primary and secondary students (n=465) participated in 20 projects, that reached the Experimentation and Evaluation phases of the Living Lab methodology. Students responded to a questionnaire before and after their project implementations. Analyses indicated significant results for digital and services with real people prototypes. However, physical prototypes had no effect on the intrinsic motivation, self-efficacy, or civic engagement of students. Overall, the types of prototypes students develop when following a Living Lab methodology promote their active community participation, the dissemination of co-creation initiatives, and affect the levels of their intrinsic motivation, self-efficacy, and civic involvement.

955 Stellarium Gornergrat – a Swiss Remote-Controlled Observatory for Education and Public Science

Andreas Mueller[1], Sylvia Ekstroem[1], Stéphane Gschwind[1], Sascha Hohmann[2], Timm Riesen[3]

[1]University of Geneva, Geneva, Switzerland. [2]University of Paderborn, Paderborn, Germany. [3]University of Bern, Bern, Switzerland

Abstract

The Stellarium Gornergrat is the first remote-controlled observatory in Switzerland dedicated to public and educational use. It allows to carry out high quality observations through five professional instruments. We report about the research-based development of student activities and educational units, realised in the framework of a researcher-teacher partnership.

Activities are available for target audiences from primary school to high school, including options for student research projects, and cover astronomical topics from near space through the solar system and the milky way to far-away galaxies. Quantitative and qualitative performance indicators are given, and perspectives for future development are discussed.

1053 Which Teachers Visit Out-of-School Learning Environments?

Lorenz Kampschulte[1], Felix Müller[2], Anje Ostermann[2], Anke Lindmeier[3]

[1]Deutsches Musuem, Munich, Germany. [2]IPN, Kiel, Germany. [3]University of Jena, Jena, Germany

Abstract

Visits to out-of-school learning environments (OSLE) are becoming increasingly popular. Due to their diversity, they offer very different supplements to the classroom - like to deepen knowledge, gain practical experience, or build stronger connections to the everyday world. In this study, we investigate for the country of Germany which teachers visit OSLE, what influences their visiting behavior, and how much time they use for preparatory and follow-up lessons. It is found that teacher characteristics such as age, experience, or gender do not influence behavior. The subject taught and especially the number of subjects taught, on the other hand, have a clear influence on the frequency of visits and the choice of learning venue. The time spent on preparation and follow-up after the visits varies greatly for the different learning sites.

1210 Effects of Out-Of-School Learning on the Stem Biography of Primary School Students

Jan Roland Schulze, Annkathrin Wenzel, Eva Blumberg

Paderborn University, Paderborn, Germany

Abstract

Disturbing results of recent research findings of TIMSS 2019 (Trends in International Mathematics and Science Study) on primary and secondary school students' deteriorating science literacy prompt an inevitable urge to improve basic science education (Schwippert et al., 2019). In Germany, overall levels of science literacy have slightly declined over years and a wider distribution of skills among students has emerged, with most students demonstrating inadequate competencies in science education at the end of primary school on the verge of entering secondary school. In general, there is a noticeable general decline in interest and perceptions of features that promote comprehension and interest among students in the transition from primary to secondary school. (Möller, 2014). The present project aims to optimize the transition of science and technology learning from primary to secondary level through the symbiosis of out-of-school learning locations and the use of digital media. In addition, cross-school level offers (grades four to six) on scientific, ecological, and technical issues in the context of an education for sustainable development are to be developed, including a blend of (out-of-school) learning locations and digital media use. Finally, the

implementation of these topics in the teacher qualification of science education at university is another important milestone of the presented project. Out-of-school learning is a curricular learning experience outside the classroom that provides students with significant opportunities for observation as visually detectable change in processes (Blaseio, 2015). Out-of-school learning provides students with real-world opportunities for genuine experiences with phenomena in their environment that cannot be replicated in the classroom because they lose their authenticity. In addition, out-of-school learning experiences are diminishing in curricula as they are increasingly substituted by information and communication technology (ICT). A merging of ICT and out-of-school learning activities, and an evaluation of their academic potentials and benefits is still pending.

Parallel Session - 1.18 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Greses Perez

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396 Plant Favouritism: A Critical Discourse Analysis

Khalifatulloh Ardh[1], Zamzam Nursani[2]

[1]Okayama University, Okayama, Japan. [2]SMAK BPK Penabur 1 Bandung, Bandung, West Java, Indonesia

Abstract

The present study aimed to explore the influence of plant characteristics, including both form and function, on the selection preferences among prospective science teachers in Indonesia. The term “form” refers to the unique morphological traits of a plant, while “function” pertains to its practical utility in human life. The term “selection preferences" refers to the choices made by PSTs when selecting a plant for discussion purposes. A sample of 100 prospective science teachers participated in an introductory botany class lecture where they discussed about plants of their interest. Transcript of the discussion were analyzed through Conceptual Content Analysis and Critical Discourse Analysis to elaborate the underlying causes of the selection preferences. Results indicated a preference for plants that produce fruit and flowers (angiosperms), leading to the concept of "Plant Favouritism" as a subcategory of "Plant Awareness Disparity." (Formerly Plant Blindness) The critical discourse analysis revealed underlying causes of Plant Favouritism, including a lack of sustainability perspective and commodification of plants in the society. The study suggests choosing plants for educational purposes based on pedagogical value, not Plant Favouritism. Additionally, the present study argues for including more non-flowering plants, such as moss, ferns, and gymnosperms and their critical role in the environment for a prospective science teacher education that is more inclusive.

1211 Cultural Astronomy and Science Education: Diversity and Cultural Heritage

Cristina Leite[1,2], Marta Souza[2]

[1]USP, São Paulo, Brazil. [2]Pós-graduação Interunidades em Ensino de Ciências - USP, São Paulo, Brazil

Abstract

This work presents cultural astronomy as a possibility for approaching diversity and cultural heritage in the context of science education, bringing some specificities of this scenario in Brazil. Cultural astronomy is the study of the relations between humanity and astronomical phenomena, highlighting the cultural bias. Although there are different actions that encourage the work and appreciation of cultural diversity in education, the construction of didactic proposals with this perspective is challenging. Based on this problem, the objective of this work is to discuss the elements that can structure thematic approaches in cultural astronomy. To this end, the work is proposed from three aspects. The first of these is the approach to the history and culture of the original peoples, working as a tool to integrate knowledge about the sky with the way of life and to present new narratives in which the original peoples can tell their own story. The second aspect refers to exploring the theme of sky mapping and the approach to constellations from the perspective of different cultures, given that there is a vast production in cultural astronomy in this area. The last element concerns the work with mythical narratives, in view of the potential that myth has to present another logic of thought, beyond Cartesian thinking. Finally, the approach to cultural astronomy can contribute to forming subjects who are open to the exchange of cultures and to valuing our cultural heritage.

1225 Justice-Centered Engineering and Science Audience for Multicompetent Learners

Greses Perez

Tufts University, Medford, MA, USA

Abstract

This article puts forward the framework of justice-centered engineering and science audience (JESA). Building on the variationist sociolinguistics traditions and justice science research, this study examines the contradiction of Black and Brown undergraduates, especially Latino/a/x, who have seats at the engineering and science table but are excluded from having an audience and a voice in the technical and scientific disciplines. Using a mixed-method sequential explanatory design, this study investigates the factors students consider in language use at home and school. Through analysis of variance of students' responses to a survey and semi-structured interviews, the findings suggest that students first consider the audience in choices about language and, to a lesser degree, topic, and settings. It illustrates why in some cases people might no longer feel capable of discussing something using a particular language because they have not had experiences in engineering work in that language nor anyone who

models those practices for them. The data exposed the link between lack of representation of Black and Brown faculty in the disciplines and language preferences in university settings. This work draws attention to the importance of thinking about who the professors are in engineering and science, and the messages that representation sends to students about technical and scientific audiences.

Parallel Session - 1.19 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Rie Malm

489 The Spatial Dimension of Practical Work: Mechanisms of Exclusion in Fieldwork and Lab-Based Teaching in Higher Education

Rie Malm, Marie Ryberg

University of Copenhagen, Copenhagen, Denmark

Abstract

Practical work is often highlighted as having a potential for high quality learning, and as a key component of research-based teaching in higher education. While critics in science education have pointed to the lack of clarity about the conceptions and aims of practical work, few have pointed to the mechanisms of in- and exclusion involved in practical work. This paper examines the intersection of tacit knowledge with student identities, focusing on the spatial dimension of practical work in higher education. Comparing ethnographic studies of fieldwork in geology and lab-based teaching in the experimental sciences, the paper shows that the ways in which students and teachers are distributed in space manifest patterns of in- and exclusion. Combining theories of tacit knowledge with recent theorizing of space and exclusion in education, the paper discusses the consequences of such basic aspects as proximity to teachers and access to interaction for who benefits from practical work. The paper argues that a clearer conception of practical work requires attention to the spatial dimension and its implications for the educational opportunities of students to access and interact with teachers.

504 Investigations of Middle School Students' Opinions Related to Performance-Based Science Education

Ilgım Özergün, Betül Timur

Çanakkale Onsekiz Mart University, Çanakkale, Turkey

Abstract

There have been a significant expectations on all over the World to participate students in science, technology, engineering and mathematics (STEM). However, both recruitment and interest in STEM related career choices decreased in all over the World. Recent studies have shown that Therefore, the aim of this research was to explore middle school students' attitudes on performance-based science activities. In this descriptive survey study participants was 226 students. Data was collected during 2022-2023 fall term from middle schools (5th to 8th grade). Data collection tool was adapted and implemented. The data collection tool has different type of questions including demographic, Likert types, and open ended. For this reason, as a data analysis both qualitative and quantitative analysis methods was used in order to observe differences in gender and grade level. According to the preliminary results, less middle school students wants to pursue career in STEM related jobs. Most boys thought that engineering is a male job whereas nursing is a female job. On the contrary most of the girls think that jobs has no gender. In addition to that, both girls and females know more male scientists than female scientist. Almost half of the middle school students did not state any woman scientist. Other findings related to the middle school students' opinions related to performance-based science education stated that most of them have positive opinions about science is important but ironically most of them said that science is not for them but clever people. This research's findings has implications to scientist image, gender inequalities and career choice in STEM.

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517 Laughing and Subverting the Chemistry Curriculum: A Critical Ethnographic Analysis of Brazilian High School Students' Identity Work Through Humor

Matheus dos Santos Barbosa da Silva, Ana Cláudia Kasseboehmer

University of São Paulo, São Carlos, São Paulo, Brazil

Abstract

This study draws upon Mikhail Bakhtin's theory of the carnivalesque, Pierre Bourdieu's notion of social space, symbolic power and doxa, and the construct of science identity, to understand how marginalized Brazilian high school students' subversive practices (humor and laughing) in chemistry classes act as a tool for doing identity work as chemistry learners. Analyzing ethnographic data collected from two suburban public schools in Brazil which are mostly attended by working-class communities, we document how high school students constructed a bakhtinian carnival-like chemistry class through humor and laughter. We analyze how students invoke laughter and humor to position themselves as playful students and significant members of the peer group, while simultaneously working to be good Chemistry learners in class, toning down the seriousness of chemistry lessons, and constructing a milieu that exudes a sense of belonging and solidarity. This study contributes to the debates surrounding the issues of structure and agency in science identity studies by focusing on the relationship between the formal organization of the chemistry curriculum and students' playful practices that reflect subversion and resistance.

Parallel Session - 1.20 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Derya Kaltakci-Gurel

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3 Quality Management and Student Needs: Student Evaluations of Lecturers' Online Classes

Thelma De Jager

Tshwane University of Technology, Pretoria, Gauteng, South Africa

Abstract

Various studies have shown that student-lecturer evaluations could enhance quality management and address students' learning needs. Most students experience various challenges during online teaching that does not always address their needs and interests. To detect their needs, Science and Mathematics student-teachers evaluations of their lecturers' classes is essential. A quantitative approach was used to establish effective online teaching. Student teachers (n=112) taught by the same three lecturers evaluated their lecturers online. Findings and results showed that most of the students felt anxious when they had to learn online, that they need frequent and timeously feedback on their assignments, more online small group discussions should be held, lecturers should facilitate the learning of new content and assist them if they encounter challenges and use interesting methods that are exciting.

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86 Development of a scientific practices survey for middle school students

Yann Shiou Ong, Yew-Jin Lee, LUKE GEK SIONG LIAU, Xu Kang Tan

National Institute of Education, Singapore

Abstract

The new Singapore science curriculum framework has been revised to incorporate an important domain--the Practices of Science--which closely aligns with the US Next Generation Science Standards' scientific and engineering practices in the local form of Ways of Thinking and Doing (WOTD). Given a lack of appropriate survey instruments for evaluating students' grasp of scientific practices for large groups of learners in a pragmatic way, we set out to develop such an instrument, in anticipation of research and assessment needs. Two versions (A & B) of a scientific practices survey instrument were thus constructed and validated in a pilot study with middle school students (Grades 7-8) in a Singapore secondary school (n=107 for version A; n=89 for version B). Our items were lean in science content, but scientific practices rich and inspired by scientific investigations reported in science journals/popular science websites. They mapped onto practices in the three spheres of scientific activity: investigating, evaluating, and explaining. All items were validated and achieved reasonable inter-rater reliability based on Cohen's kappa measure. Rubrics for each item were written to reflect four

performance levels: extending (highest), proficient, developing, and emerging (lowest). Pilot study findings suggest the majority of students were operating at the developing level: Many students did not demonstrate a grasp of the scientific practices, but instead, followed typical "school science" practices.

101 Development of a Digital Instrument to Measure Students' Abilities in Scientific Inquiry Processes in the Subject Biology as Part of a Screening Procedure for Scientific Giftedness

Colin Peperkorn, Claas Wegner

Bielefeld University, Bielefeld, Nordrhein-Westfalen, Germany

Abstract

Screening procedures in giftedness diagnostics can enable a first impression of present abilities in a larger group of students. However, their composition is a sensitive issue, because the used instruments must not lead to issues such as the neglect of certain groups of students (Renzulli & Reis, 2021). To date there is no instrument to measure abilities in scientific inquiry processes in primary and secondary school students, which meets the aforementioned requirements and would be suitable for a screening procedure in scientific giftedness. In this study, 54 items on abilities in scientific inquiry processes (based on Nowak et al., 2013) were developed and initially tested in three different questionnaire forms. The sample of the pilot study consisted of N = 163 students (mean age = 9.35 years; 43% female, 53% male, 4% N/A.). The item analysis showed that 8 Items of the original pool need to be revised. Further analysis of raw score distribution does not indicate major design errors in any of the questionnaire forms. In a possible presentation, a closer look at the item development and first results will be shown. Furthermore, the revision process of the eliminated items, special features of the developed test procedure, and possible application fields of the developed test will be discussed.

511 Investigating Gender Differences in Confidence and Accuracy in the Force Concept Inventory (FCI)

Derya Kaltakci-Gurel

Kocaeli University, Kocaeli, Turkey

Abstract

Confidence is defined as students' belief in their own ability. According to the confidence paradigm students report how confident they are in the accuracy of their responses in an exam. It is considered as mis-calibration if there is a mismatch between accuracy and confidence. Bias is obtained by subtracting the mean accuracy score from the mean confidence score. Previous research revealed that individual differences such as gender, influences confidence and bias scores. The aim of the present study is to investigate the effect of gender on freshman students' performance and confidence in the Force Concept Inventory (FCI). Eighteen items from the FCI were administered to 369 (nfemale=185, nmale=184) freshman physics students in a state

university in Turkey. Each FCI item was featured with an item asking students' confidence in answering the item correctly. The independent samples t-test was conducted to compare the confidence scores and FCI scores for male and female students separately. Results indicate that gender differences were exist both on confidence and FCI scores. Whereas the effect sizes were found to be medium in confidence and small in the FCI scores, respectively. The implications of the results for teaching and learning will be discussed in the study.

Parallel Session - 1.21 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Tamar Traube

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697 Longitudinal Interest in Science and Project-Based Teaching in Primary/ Upper Secondary School – Findings and Methodology From the Danish Leaps-Project 2018-2021

Lars Bang Jensen, Lea Høxbroe Højbjerg

Aalborg University, Aalborg, Denmark

Abstract

This paper highlights some of the quantitative findings from the Danish LEAPS-project (Andreasen, Jensen, Knudsen & Ørngreen, 2022) and supplies a new methodological approach examining interest in science through a three-legged index, termed TRI-SCINT. The LEAPS-project is a school initiative, where the enrolled schools over time change their pedagogy and teaching to the approaches outlined in LEAPS. LEAPS is inspired by PBL and can be seen as a somewhat strong conceptual program aimed at facilitating cross disciplined project-based pedagogy and teaching in the primary school with a special emphasis on science. LEAPS stands for Learning and Engagement and through Authentic Projects with an emphasis on Science. Aalborg University conducted an independent study on the attitudes and experiences of the pupils from the four LEAPS-schools involved in the project, using a mixture of quantitative (a 3-year longitudinal survey) and qualitative methods (pupil group interviews) in the period 2018-2021. This paper reports primarily from the quantitative part of the study and the findings from the constructed indices regarding pupil interest in science. The novelty of the study is the construct of three indexes, termed TRI-SCINT, and how they account for student interest in science. The indices show a novel way to methodologically approach and tentatively measure interest in science. In the longitudinal study we see how the change in teaching setting affects student interest in science and overall interest in school. The indices are constructed through exploratory PCA-analysis and the questions are generally inspired by the Danish Rose-survey and similar studies of interest in science in a Nordic context. The survey questions were constructed with an emphasis on pupil activity and habits in both school- and home setting. Generally, interest in science were perceived in the study as a phenomenon

related to pupil activities and habits, simultaneously involving affective and cognitive dimensions.

1083 What Are the General Characteristics of the Research Examining the Effect of Stem Education on Higher-Order Thinking Skills?

Şeyma Irmak[1], Fitnat Kaptan[2]

[1]Amasya University, Amasya, Turkey. [2]Hacettepe University, Ankara, Turkey

Abstract

This research presents a systematic review of the literature on the effect of STEM education on students' higher-order thinking skills, which is one of the main goals of STEM education. This systematic review aims to determine which variables the current research focuses on and directs the literature to search for missing or less concentrated variables. For this purpose, nine databases were searched, and thirty-six studies were reached that met the specified inclusion and exclusion criteria. The categorical characteristics of each study were examined. As a result, it was understood that the number of studies was limited in terms of the following variables; preschool students, engineering, establishing cause-effect relationships, etc. skill types, mathematics and informatics disciplines. Concentrating the research to be carried out on these variables may enable to deepen of knowledge about STEM education.

775 An Analysis of Self-Regulation in a STEAM Project for Primary Education From Students Perspective

Maria Dolores Lopez[1], German Ros[1], Amelia Calonge[2]

[1]University of Alcala, Alcala de Henares, Madrid, Spain. [2]University of Alcalá, Alcala de Henares, Madrid, Spain

Abstract

When we talk about self-regulated learning, we mean that the learner is regulating their own behaviour, focusing it on the acquisition of an academic content, skill or task. This concept includes aspects related to cognitive self-regulation and emotional self-regulation. Moreover, the ability to self-regulate is an essential aspect of STEAM education. This study aims to analyze how primary education students, who participated in a STEAM project, perceive their own learning process in aspects related to metacognition and self-efficacy, as well as their enjoyment during the activities. In addition, connections between these aspects are analyzed. In this project, 109 students aged 9-11 years participated. The results show that students have a high appreciation for STEAM work through these types of projects as they allow problem solving and critical thinking associated with the development of satisfaction and positive self-concept in doing so. These different aspects also show significant correlations between them which is favoured by the designed STEAM project.

899 Applying Neuropedagogy-Based Visual Literacy Strategies as a Tool to Improve Students' Achievements in Organic Chemistry: A Preliminary Study

Tamar Traube[1], Inna Shvarts-Serebro[1], Debora Marchak[2]

[1]Bar-ilan University, Ramat- Gan, Israel. [2]Weizmann Institute of Science, Rehovot, Israel

Abstract

Organic chemistry is considered to be a complicated subject, identified by many studies as an area of difficulty for learners. To succeed in this topic, students must master the names and equations belonging to the complex conventions of the organic chemistry language and use multiple types of visual representations that are meant to signify molecular structures and characteristics, as well as the processes that molecules undergo during chemical reactions. Despite educators' attempts to apply varied teaching strategies, organic chemistry remains a subject that relies heavily on visuo-spatial thinking and visualization. Thus, many students struggle to make the conceptual, visual transition between the macro, submicron, symbolic, and process levels of understanding involved in multi-level thinking. In this study, we set out to investigate one implication of educational neuroscience for the teaching and learning of organic chemistry: addressing students' visual thinking skills, necessary for integrating new and complex visual input, through verbally-mediated reasoning. The intervention consisted in training organic chemistry students in visual literacy. With this aim, we developed 10 content-related, visual literacy exercises based on visual thinking strategies and neuropedagogical understandings. These were introduced along the semester in otherwise traditional lectures; while keeping up with the rapid teaching rate required by the university curricula. Through these exercises, students explicitly learned how to observe, read, interpret, and generate graphical displays used in organic chemistry. Regardless the large size of the class, we found a significant correlation between performing the visual literacy tasks and students' achievements. Moreover, students' self-reported attitudes towards the impact of the intervention on their organic chemistry related visuo-spatial capabilities were positive. Our results suggest that implementing neuropedagogy-based visual literacy strategies to organic chemistry teaching and learning has the potential to improve, with minimal effort, students' understanding of the subject.

Parallel Session - 1.22 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Liam Guilfoyle

93 Supporting Preservice Teachers in Analysing Curriculum Materials: Findings of a Design-Based Research Project

Markus Obczovsky[1], Claudia Haagen-Schützenhöfer[1], Thomas Schubatzky[2]

[1]University of Graz, Graz, Austria. [2]University of Innsbruck, Innsbruck, Austria

Abstract

Science education research aims at improving the quality of teaching and learning science in school. A common approach in science education research to improve this quality is by developing and providing curriculum materials (CM) to support teachers designing instruction in classroom. These CM are often innovative and new for teachers. However, many CM address students rather than teachers and features of the CM that are supportive for student learning are not explicated to teachers. Studies indicate that teachers struggle identify some features in CM that are supportive for student learning or reject some of these features. Therefore, we investigate how to support preservice teachers in science education programs in analysing CM to discover different features of CM, reflect upon their role for student learning and decide whether they are relevant for student learning. For this purpose, we iteratively developed a prototypical teaching and learning sequence (TLS) for science teacher education programs in a design-based research approach. We implemented two versions of the TLS in a bachelor seminar of our physics teacher education program so far with eight and 13 preservice teachers. In a mixed methods approach, we conducted interviews, used text vignettes with open questions and collected several learning products. The preservice teachers of our study tend to struggle with justifying their decision why features are supportive for student learning and often draw on content knowledge or common sense rather than pedagogical content knowledge. Throughout the TLS a shift of focus in the preservice teachers' argumentation from content of CM to the strategies for teaching or learning the content used in CM can be seen. The preservice teachers generally accepted the TLS and the strategy provided to analyse CM. In an oral presentation we will discuss the findings and our drawn conclusions for the adaptions of the TLS.

1082 Inquiry-Based Fieldwork - From Experiences in Student Role to Reflections on Teacher Role

Jørgen Stange Larsen[1], Bernt Rydland Olsen[2]

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Abstract

Despite clear recommendations from the research field that fieldwork should be explorative, and student centered, school practice is not characterized accordingly. In this study, an inquiry-based fieldwork activity, was developed for science teacher education, and conducted in both freshwater, and marine ecosystems. Data was collected autumn 2023, and a thematic analysis on preservice teacher`s (PST`s) written reflections, from 3 student groups, was conducted. Four

themes were identified and categorized accordingly. The analysis revealed contrasting views among the informants, where one group considered inquiry as combination of scientific practices, and another group of informants emphasized solely on data collection. The informants also suggested several relevant ideas for adaptation to school practice and reflected on the teacher role. However our findings indicates that they struggled to differentiate open/closed inquiry from scaffolding, support, and structure. Furthermore, PSTs with a singular emphasis on data collection may view inquiry's practical aspects as most explorative or may not fully grasp the different practices contributions in arriving at durable answers.

1162 Threshold Concepts and Threshold Epistemes: From Science Education to Teacher Education

Liam Guilfoyle[1], Jenny Wynn[1], Matthew Dunn[2]

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Abstract

When one begins to learn a discipline, particularly through a structured curriculum, one encounters 'key' or 'core' concepts which are the necessary building blocks within the discipline. One approach to thinking about deep learning across many disciplines has been the Threshold Concept Framework (TCF) (Meyer & Land, 2003). Threshold concepts are qualitatively different from core concepts in that they hold the potential to transform learners' views of their discipline like a '...portal, opening up a new and previously inaccessible way of thinking about something' (p.1). The TCF has most often been applied in the context of learning subject disciplines, such as biology or mathematics, and recently in initial teacher education (ITE) in the process of learning to teach these disciplines (Authors, forthcoming). However, when learning to teach one is not simply learning the subject matter of their discipline, but also learning other elements of teacher professional knowledge (Carlson & Daehler 2019). In this paper, we apply the TCF to the 'discipline' of education and explore the threshold concepts in learning to teach. Applying methodologies often used in exploring threshold concepts, we consult preservice teachers (PSTs) (n=302) to understand the concepts which they found most troublesome in learning to teach, and their 'lightbulb moments' in initial teacher education. We analyse these threshold concepts through teacher educator literature and experience to identify "threshold epistemes" which underpin and connect the threshold concepts. The findings are considered with respect to how values may interact with PSTs' evaluation of the concepts as troublesome, and whether their experience at the end of ITE would be sufficient to have 'stepped through', and therefore identify, the threshold concepts. We discuss the implications of threshold concepts for the practice of teacher education and approaches for further research.

1078 Pre-Service Science Teacher's Opinions on Science and Engineering Based Course Design and Their Views: The Effect of Climate Change on Cultural Heritage

Elif Benzer[1], Gülfem Muşlu Kaygısız[2]

[1]Marmara University, İstanbul, Turkey. [2]Hasan Kalyoncu University, Gaziantep, Turkey

Abstract

The purpose of this study is to determine the level of pre-service science teachers' teaching plans designed in order to stop the negative impacts of climate change on Turkey's Cultural Heritages and their views on this subject. To achieve this aim, multiple case design was used. The research was carried out with 47 senior-year pre-service science teachers studying in the 2022-2023 academic year. The lesson process continued for three weeks. In this three-week cultural heritage is discussed along with the effects of climate change, cross-cutting concepts, and the framework of science and engineering practices, which are all taught through a sample lesson plan. 20 days after completing the training, the pre-service teachers were asked to submit their teaching plans. Two different forms were used in order to answer the research questions. One is the pre-service teachers' prepared lesson plans and the other is the self-evaluation form. The teaching plans prepared by the pre-service teachers were analyzed with a rubric prepared by the researchers. The pre-service teachers were asked to complete a self-evaluation form and this form was evaluated descriptively. The results of the study will be presented later since the application was completed recently.

Parallel Session - 1.23 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Sevil Akaygün

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424 Exploring the Effects of Model-Based Inquiry on Pre-Service Primary Teachers' Outcomes: Content, Epistemic and Pedagogical Knowledge

Miguel Romero-Gutiérrez, María Martínez-Chico, Rafael López-Gay Lucio-Villegas

Universidad de Almería, Almería, Spain

Abstract

The need to promote scientific practices in primary schools imply that teacher education should focus efforts in incorporating them into teachers' future instruction. A determining issue in order to improve the training process is to identify teacher training designs that ensure successful results regarding the pre-service teachers' pedagogical content knowledge. Despite the critical role that scientific practices focused- courses play in the teachers' knowledge development processes and outcomes, the investigations focused on a deep evaluation of these courses are

seldom found. In this study, the effect of a Model-Based Inquiry cantered course on Pre-service Primary teachers' knowledge is explored. To this end, we analysed their answers to multiple choice contextualized tests to know how impact on scientific (content and epistemic) knowledge and pedagogical knowledge. These findings on the domain of the different contents are discussed so that they contribute to the understanding the effects of incorporating the MBI approach in initial teacher training.

461 Place'ing Doubt Within Pre-Service Teacher Education

Maria Rejkjær Holmen, Jeppe Langkjær, Bjørn Friis Johannsen

University College Copenhagen, Copenhagen, Denmark

Abstract

This two-part study on students' choice-narratives, self-understanding, and praxis in relation to a science Honours College (HC) at a preservice teacher programme in Denmark shows how sense of belonging mediated through place and room for doubt are pivotal to their meaning-making. The study departs from an interest in the students' praxis related to the HC that was created with the intention of attracting more students to the STEM-field and empowering their self-understanding as future science teachers. Through agonistic interviews with students that did not apply for the HC, the first part of the study finds how they rule out the programme because it requires their entire dedication leaving no room for doubt and uncertainty. Using interviews supported through photo-elicitation, the second part of the study shows how students' longing for spatial belonging to the general teacher education was a strong reason for applying to the HC. In line with a social constructivist understanding of learning and identity we therefore suggest that a fulfilment of the ambition to attract and retain more and better science teachers relies on a stronger focus on the material aspects of education and on making a place where students experience the legitimacy of doubt and error as their self-understanding as teachers emerge and transform.

682 The Effect of Feedback and Reflection on Preservice Science Teachers' Lesson Planning Skills

Ilgım Özergün[1,2], Sevil Akaygün[2]

[1]Çanakkale Onsekiz Mart University, Çanakkale, Turkey. [2]Boğaziçi University, Istanbul, Turkey

Abstract

Feedbacks and reflections are two significant components that merge theory and practice in preservice teacher education. The aim of this study was to investigate the changes in the preservice science teachers' lesson planning skills through feedbacks and reflections. By this aim ten volunteer preservice science teachers participated in this phenomenographic study. Data were collected through the reflections written by the preservice teachers on these feedbacks. For data analysis constant comparison method was utilized. Revealed categories for instructor feedbacks were reflectiveness, timing and content. In addition to that, revealed

categories for peer feedbacks were reflectiveness, timing, content, and accuracy. The results of the analysis showed that the preservice science teachers found instructor's feedbacks more effective in progressing lesson compared to peer feedbacks. Further, it was also observed that the nature and frequency of high-level reflective thinking indicators increased from the first reflection task to the last reflection task continuously. Overall, this study has implications for the improvement of science lesson planning practices through feedback and reflection lenses.

710 Investigating the Effect of Argument-Driven Inquiry in Pre-Service Science Teachers' Self-Efficacy to Teach Science Through Argumentation

Pınar Seda Çetin[1], Gülüzar Eymur[2]

[1]Bolu Abant İzzet Baysal University, Bolu, Turkey. [2]Giresun University, Giresun, Turkey

Abstract

The main aim of this study is to investigate the effect of Argument-Driven Inquiry (ADI) on pre-service science teachers 'argumentation self-efficacy. Thirty-eight first year pre-service science teachers participated in intervention. Intervention included six ADI laboratory activities in the first semester, and they were asked to design their own ADI activities in the second semester. A mixed method that including qualitative and quantitative method was used in the study. For quantitative data, Argumentation Self-efficacy Scale was adapted and used. The semi-structured interviews were used to collect qualitative data. The results showed that pre-service teachers gain significant improvements teach science through argumentation between pre- and post-test.

Parallel Session - 1.24 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Manuela González-Herrera

186 Teacher Educators Cooperating Professionally: New Practices, Tensions and Student Teachers' Experiences

Birgitte Lund Nielsen[1], Niels Anders Illemann Petersen[2], Claus Auning[3], Bjørn Friis Johannsen[4], Jens Dolin[5]

[1]VIA University College, Aarhus, Denmark. [2]University College of Northern Denmark, Aalborg, Denmark. [3]University College Southern Denmark, Haderslev, Denmark. [4]University College Copenhagen, Copenhagen, Denmark. [5]Department of Science Education, University of Copenhagen, Copenhagen, Denmark

Abstract

In the context of a large-scale initiative to improve science teaching in Danish primary and lower secondary schooling, teacher educators from the six Danish University Colleges are working to develop a culture of professional learning communities (PLC). The paper presents research from the first phase of this initiative examining the developmental and collaborative practices initiated by the science teacher educators and how the student teachers are positioned in the professional inquiry projects run by the PLCs. The research design is a sequential mixed methods design with a range of interviews with teacher educators in the first exploratory phase and concurrently informing a questionnaire developed for the next phase. Data about student teachers (n=163) is from a survey with questions and open reflections about their perceived outcomes. Findings related to problems and benefits of working in PLCs and to involving student teachers in the PLC activities will be presented. Especially the theme of second-order teaching in teacher education with a possibility for explicit modelling will be addressed, as well as the importance of giving student teachers ownership to projects within the PLC.

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194 Development and Evaluation of a Practical Course for the Technology Teacher Training

Dorothee Ermel, Josef Riese

Paderborn University, Paderborn, Germany

Abstract

High-quality teacher education is the basis for high competences of future teachers. To prepare them adequately for the demands of their future teaching profession, it is essential to know (i) which subject-specific competences and skills they need and (ii) how these can be acquired in teacher education. However, empirical findings on necessary competences as well as on the design of teacher training courses are scarcely available on the subject of technology, especially regarding technical-practical courses. The acquisition of such practical competences and skills is of great importance for the subject of technology when, for example, machines are operated, tools are used, or objects are designed and manufactured. To fill this gap, the presented study focuses on the theory- and empirically-guided development and evaluation of a specialised practical course. The development was structured as an iterative process. In a first step, the competences to be acquired were described and structured, taking normative perspectives into account as well as an empirical needs assessment among teachers and teacher educators. In a second step, the student teacher´s perspective was surveyed to adapt the course to their previous competences, skills and experiences. In a third step, the content and the didactic structure of the practical course had iteratively been developed, considering the findings of the preceding steps. The practical course was taught in several runs and evaluated with respect to the perceived learning outcomes of the student teachers as well as to the quality of the course. The evaluation was carried out through self-assessment of the students in a questionnaire and a written portfolio. The findings of the evaluation indicate a positive perception regarding the quality of the course. Furthermore, an increase in practical

competences and skills such as the handling and using of different equipment was found.

341 Pre-Sevice Science Teachers' Opinions About Being a STEM Teacher: A Pilot Study Based on the Perspective of STEM Teacher Identity

Emine Eren, İlbilge Dökme

Gazi University, Gazi Faculty of Education, Science Education Department, Ankara, Turkey

Abstract

With the integration of STEM, science education evolves into practices aiming at developing real-life problem solving, engineering, and design skills. This evolution reveals the importance of being a STEM teacher. Knowing how pre-service science teachers define being a STEM teacher and to what extent they identify themselves as a STEM teacher is very important for the future of science education. For this purpose, semi-structured interviews were conducted with 28 pre-service science teachers. The responses of the pre-service teachers were analyzed by content analysis. According to the findings, pre-service teachers think that teachers who effectively use technology and integrate it into their lessons, have sufficient content knowledge, and associate their knowledge with different disciplines are STEM teachers. Another important finding is pre-service teachers consider themselves STEM teachers in the future and have some motivations for this goal.

411 Study of Emotional Climate and Flow Experienced by Pre-Service Teachers During a Model-Based Inquiry Teaching-Learning Sequence About Living Beings

Manuela González-Herrera, Luis Delgado-Mayoral, Maria Martinez-Chico, Rut Jimenez-Liso

University of Almeria, Almeria, Spain

Abstract

The absence of inquiry-based approaches in Spanish science classes has led us to design a Pre-service Primary Teachers (PPT) training course in which the PPT experience the Model-Based Inquiry (MBI) approach "as learners" and become aware of what they have learned and felt. In this study, the emotions PPTs feel during a MBI sequence on living beings is explored, and those emotions are analyzed from the perspectives of emotional climate and flow. Results show the tasks that favor a better emotional climate were those in which PPTs have to express their initial ideas and draw conclusion to answer the trigger question; and moments with a greater number of students experiencing flow are those in which participants have to express their initial ideas and design experiments to test them. This study adds to the limited research around the MBI approach effects in relation to emotions, emotional climate and flow in science teacher education.

Parallel Session - 1.25 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Jasmin Kilpeläinen

32 Undergraduates' Underachievement in Science Technology Engineering and Mathematics: Exploring Opportunity and Access for Sustainability

Olalekan Taofeek, Loyiso Jita

University of the Free State, Bloemfontein, Free State, South Africa

Abstract

Growing human capacities in STEM remain the most practicable way to solving present and future challenges. Improved test scores, access to opportunities to learn, resources and facilities have been recommended in the literature to build capacity and improve achievement for effective and qualitative delivery in STEM classrooms. We focus on the two primary stakeholders in teaching and learning in the university who are students and lecturers. This manuscript explores the causes of underachievement among undergraduates in STEM fields by employing a mixed method for data collection among 100 undergraduates and 45 lecturers from six public universities using purposive and quota sampling. Three main research questions were raised on students, lecturer and institution base factors along with perceived hindrances to STEM learning and teaching. Three instruments of Students Factors for Underachievement (SFUA), Lecturers Factor for Underachievement (LFUA) and Lecturers Perceived Factors for Underachievement (LPFU) were employed for data collection through survey and interview. Among other findings, ignorance among learners, non-utilization of instructional resources, inaccessibility to library and laboratory and it resources were principal hindrances of undergraduates, lecturers and institution-base factors. The study concluded that efforts and better commitment is needed from stakeholders to alleviate the present situation and recommend interventions to remediate areas of need.

352 How Tertiary Science Students' Experienced Study Environment Affect Dropout

Ane Qvortrup, Eva Lykkegaard

University of Southern Denmark, Odense, Denmark

Abstract

In this paper we investigate how tertiary science students' perceptions of study environment explain variations in their dropout considerations and actual dropout. Referring to Tinto's (1974) Institutional Departure Model and a systematic review of dropout literature, the study environment is operationalized by an academic system, a social system and teaching. Multivariate statistical analyses are used on longitudinal data in the form of half-early register

and survey data from all Natural Science students at a Danish University since 2019 collected as part of the research project "Data-driven Quality Development and Dropout minimization". The paper finds that study environment factors explain around 50% of the variations in science students' dropout considerations and that exact percentages and factors vary across programs and terms. We present the results from different programs and terms and, based on the results, we discuss what we can learn from the study about being a science student and about study environments that can help us to increase the number of STEM graduates in Denmark.

683 Undergraduate Science Students' Ideas and Their Evolution for Size-Dependent Properties in the Nanoscale

Ioannis Metaxas[1], Emily Michailidi[2], Dimitris Stavrou[2], Ioannis V. Pavlidis[1]

[1]Department of Chemistry, University of Crete, Heraklion, Greece. [2]Department of Primary Education, University of Crete, Rethimno, Greece

Abstract

Nanotechnology is a scientific field with well established importance it the scientific community, there is an arising need for rendering of future scientist able to compose a future "nano-workforce". Therefore, integrating this field in university education is of great importance. Although the educational significance of nanotechnology is well established it is evident that there is a lack of published research in science education literature based on well-founded theoretical framework for university education. This study is aimed at addressing this issue by investigating undergraduate science student's ideas and their evolution about the size dependent optical properties of nanomaterials via the implementation of a teaching experiment. This research was conducted with students from chemistry, physics and biology departments while its theoretical framework was the Model of Educational Reconstruction. The analysis of this implementation clarified that students appear to view optical properties as initially quantity dependent and partially size dependent. It is through activities that introduce quantum confinement and specific inputs from the researcher that these ideas can evolve to view optical properties as fully size-dependent.

1048 Review of Cooperative Learning in Higher Education Physics: Strategies, Tasks, and the Origin of Effectiveness

Jasmin Kilpeläinen, Terhi Mäntylä, Antti Lehtinen, Pekka Koskinen

University of Jyväskylä, Jyväskylä, Finland

Abstract

Learning outcomes in university-level physics can be improved by avoiding traditional lecture-centred teaching approach and favouring methods that give students a more active role. One way to activate students is to use cooperative learning, which is based on working towards a shared goal together in small groups. The aim of this systematic literature review is to find out how cooperative learning can be applied in higher education physics and what are the reasons

behind its effectiveness. We used three research databases to identify studies focusing on cooperative learning of physics in higher education and found 36 articles published between 2010 and 2022 for review. We used qualitative content analysis to recognize the cooperative learning strategies, tasks used during the activities and the arguments for the effectiveness of studied strategy. A total of eight different strategies appeared in reviewed studies, of which Learning together, Jigsaw and Group inquiry were the most common ones. Multiple kinds of tasks were used, for example, mathematical, conceptual and experimental. We identified 12 different arguments for the effectiveness, and each of them was related to either intraindividual or interindividual interactions or the environment. Thus, cooperative learning can be applied in various ways and there are multiple reasons for using it. However, it should be studied more precisely in this context, as many of the reviewed studies were done with a small number of participants or without a proper control group. Also, as the selection of tasks was rarely justified, research should focus more on the influence of the tasks.

Parallel Session - 1.26 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Rasmus Høiby

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122 Education Technologies: Science Teachers' Competencies of Using Education Technologies

Özkan YILMAZ[1], Taner BULUT[2]

[1]Erzincan Binali Yildirim University, Erzincan, Turkey. [2]Ministry of National Education, Van, Turkey

Abstract

In order to ensure the provision of a good education, education technologies are constantly on the agenda of education policies. Technological tools are used for solving many problems in education. Having technology by itself, however, is not enough to solve these problems. Teachers and students, who are the users of technology, need to be able to use these technological tools well. At both international and national levels, it is expected and desired for teachers to be able to use technology well. The aim of this study is to determine the level of education technology usage skills of Science Teachers working in public institutions operating under the Ministry of National Education. The study group consists of Science Teachers working in a large city in the Eastern Anatolia Region of Turkey. The study was conducted with a total of 306 science teachers. The following conclusions have been revealed with the findings obtained: (1) There is no gender difference in the level of education technology usage skills among science teachers. However, it has been found that male teachers were more successful specifically in "technology literacy." (2) Science teachers who are just starting out have the

highest level of skills in using technology. This skill tends to decline over time, and especially after 20 years, there is a decline in teachers' knowledge and skills in all fields. The skills of using of educational technologies by teachers needs to be constantly updated. To this end, it is recommended that teachers get specific specialized or professional training during their employment period. Additionally, it may be ensured that more specific trainings are provided by taking into consideration the gender factor in these trainings as revealed by the researches.

465 Understanding Science Teachers' Practices Through the Theory of Practice Architectures

Norsyazwani Muhamad Dah[1], Mohd Syafiq Aiman Mat Noor[2]

[1]Universiti Pendidikan Sultan Idris, Tanjong Malim, Perak, Malaysia. [2]Universiti Brunei Darussalam, Bandar Seri Begawan, Brunei-Muara, Brunei Darussalam

Abstract

Teachers' practices can be complex and difficult to comprehend. However, the theory of practice architectures can offer a deeper understanding of these practices, by not only seeking to understand how they are constituted but also how they shape and are shaped by the conditions of a specific context. Hence, the study utilised practice architectures as a framework to explore science teachers' practices in Malaysian secondary schools. Ten science teachers, recruited through purposive sampling from a range of secondary schools throughout Malaysia, participated in semi-structured individual interviews, which were analysed thematically to uncover four key themes. These themes were: teachers' roles in inquiry-based teaching, teachers' efforts to promote inquiry-based learning, teachers' pedagogical knowledge, and teachers' perceptions of inquiry-based teaching. The application of the theory of practice architectures allowed for a deeper understanding of the complexities of teachers' practices. It viewed the practices as a combination of saying, doing, and relating, and analysed the arrangements that enabled these practices and the forms of praxis involved. The findings of the study provide valuable insights into the challenges faced and strategies employed by science teachers in promoting inquiry-based learning, as well as their pedagogical knowledge and perceptions of inquiry-based teaching. The study highlights the significance of cultural-discursive arrangements in understanding teachers' perceptions of and attitudes towards inquiry-based learning. These arrangements must be taken into account when conducting research on the subject. Economic and social-political factors can affect the perceived workload of teachers, leading to decreased motivation. These findings contribute to the growing body of knowledge about theories of practice in the field of science education and can inform the development of teacher training and professional development programmes for the future.

550 Continuing Professional Development Program on Redox Process as a Way to Improve Chemistry Teachers Pedagogical Content Knowledge (PCK)

Luciane Goes, Carmen Fernandez

Institute of Chemistry - University of Sao Paulo, Sao Paulo, SP, Brazil

Abstract

In this work, we investigated the contributions of a continuing professional development (CPD) program on the development of chemistry teachers pedagogical content knowledge (PCK) about the content of redox reactions. To this end, a course designed to develop teachers' PCK on redox reactions was investigated. Data were collected from twenty teachers using content representation (CoRe) and lesson plans (before and after the course). Qualitative thematic analysis based on the five PCK components proposed by Park and Oliver was used for the data analysis. The results show that after participating in the CPD program, the teachers were able to develop the components independently and at different levels, with knowledge of the strategies being the most important aspect of improvement. In addition, evidence of the integration of PCK components was observed, in which the instructional strategy component was central to the integrations.

885 Exploring Partnership With Teacher Education as Professional Development for Science Teachers

Rasmus Høiby, Grethe Beiskjær, Bjørn Friis Johannsen

University College Copenhagen, Copenhagen, Denmark

Abstract

In this study we explore how teachers, who are part of a science teaching innovation project for pre-service teachers, experience their participation. We have used a qualitative approach inspired by constructivist grounded theory and conducted semi-structured interviews with five participating teachers. In our preliminary results we have found that the teachers experience their participation as a means to personal professional development and we argue that more research is needed to explore how different aspects of cooperation between science teaching in schools and science teacher education can play a part in professional development of the cooperating teachers.

Parallel Session - 1.27 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Annette Lykknes

507 "It's Only a Drawing!" - Learning to Model and About Models in Primary School

Francesco Cuomo[1], Emilio Balzano[2], Anna Merinio[3], Marco Serpico[3]

[1]Alice Salomon University of Applied Sciences, Berlin, Germany. [2]Università degli Studi di Napoli Federico II, Napoli, Italy. [3]Università degli Studi Suor Orsola Benincasa, Napoli, Italy

Abstract

Modeling is considered a key scientific practice to be addressed in science education at all grades. Current performance expectations propose that children in the early grades can learn to develop simple evidence based models to represent objects or describe phenomena, while higher level competences related to more abstract models and their use to describe relationships among variables between systems and their components are supposed to be accessible in high school. One of the three components of modeling competence, as identified in recent literature, knowledge about the use of models, their strengths and limitations, defined as meta-modeling competence, is not addressed in the performance expectations we take as reference (the Next Generation Science Standards). In a design study involving ca. 100 children over two years, we investigate the pedagogical settings that promote the development of modeling competence and the related emerging students' levels of competence in the early grades of primary school. Our findings suggest that children in second and third grade are able, in appropriate pedagogical settings, to learn to model and about models to a degree of abstraction and complexity that exceeds the current performance expectations, including developing meta-modeling knowledge.

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539 Grade 5-7 Teachers' Understanding of and Experiences with Teaching Source Criticism

Tove Grete Lie, Annette Lykknes, Marthe Lønnum, Sonia Félix

NTNU-Norwegian University of Science and Technology, Trondheim, Norway

Abstract

As part of a research project on critical thinking, funded by the Research Council of Norway, we investigate grade 5-7 teachers' understanding of, and teaching practices related to source criticism as one aspect of critical thinking. Using a mixed-methods approach, we base our analyses on a nationwide survey of 730 teachers, and thematic analysis of 11 group interviews. Analyses of the survey material reveal that teaching practices associated with source criticism vary among teachers and across subjects. Social studies teachers teach source criticism more explicitly than teachers in natural science or Standard language education (Norwegian/Swedish). The qualitative analyses show that the teachers who were interviewed see source criticism as a natural part of general education but that teaching about it comes more natural in some school subjects than others. Some teachers have experience with explicit teaching of source criticism while others do not. Many report that they spend time discussing fake news and the trustworthiness of different digital sources in their classrooms. Investigating how individual and subject specific variation in teaching and practicing source criticism influence the teaching of cross-disciplinary topics such as sustainable development emerges as a promising avenue for future research.

1022 Links Between Children's Scientific Understanding and Their Rejection of Pseudoscientific Claims Indicative of Climate Change Scepticism

Michael Allen, Simon Parry

Kingston University, London, London, United Kingdom

Abstract

Abstract. The aim was to investigate primary children's propensities to accept or reject claims that indicate scepticism towards climate change, and determine whether these propensities have links with their understanding of National Curriculum (NC) science concepts. Year 6 children (10-11 y/o, n=190) completed a questionnaire that tested their understanding of NC science related to climate change, alongside their willingness to reject a series of climate change fallacies. Quantitative analysis of data revealed that firstly, children held misconceptions of scientific concepts that form the basis of understanding mechanisms of climate change. The least understood concepts were within the topics of Earth in space and photosynthesis. Secondly, although nearly all children agreed that climate change exists and is problematic, considerable numbers were unwilling to reject statements that represented climate change fallacies. Pseudoscientific arguments sceptical of climate change citing the role of carbon dioxide were amongst the fallacies that were least rejected. Thirdly, two quantitative scales were constructed: the NC science scale represented a child's overall understanding of science concepts, and the CC fallacy resistance scale reflected a child's overall rejection of fallacies. The two scales were highly correlated, showing that children who better understood NC science also were more likely to reject fallacies. Lastly, a ranked list of science concepts was constructed, the understanding of which may confer some defence against climate change scepticism. Outcomes centre on the possibility of teachers improving children's science knowledge in order to align their views on climate change more towards the scientific consensus and away from climate change scepticism.

1132 The Effect of Inquiry-Based Science Education Integrated With Activities on Nature of Science and Socio-Scientific Issues on Science Learning of Fourth Graders

Seda Altay, Yalcin Yalaki

Hacettepe University, Ankara, Turkey

Abstract

The aim of this research was to investigate the effects of inquiry-based science teaching supported by nature of science and socioscientific issues activities on students' science learning in a primary school fourth grade science course. The study group consisted of 28 fourth year primary school students enrolled in a primary school in a low socioeconomic region of the Adana Province, in 2017-2018 academic year. To obtain detailed data about application of inquiry teaching supported by nature of science and socioscientific issues activities, the researcher, who was also the teacher, conducted the study in her classroom. The study was

designed with an action research methodology. Data collection instruments included adapted versions of Views of Nature of Science Questionnaire (VNOS-E), Views of Scientific Inquiry Questionnaire (VOSI), Inquiry Skills Test (IST), which were applied as pre-mid-post-tests, reflection writings written by the teacher and students throughout the activities, concept learning tests, and worksheets. All of the activities in the study were based on the objectives in the science curriculum. Inquiry based science education activities were designed to develop students' science process skills. The activities about nature of science were designed based on four nature of science themes, scientific knowledge is open to change, based on observation and inference, subjective, and based on creativity. In the final stage of the study, socioscientific issues activities were conducted. As a result of the research, it was concluded that inquiry-based science teaching supported by nature of science and socioscientific issues activities have a positive impact on students' views on science and nature of science and their science process skills. Students' scores on VNOS-E, VOSI, IST, and concept learning tests were improved. The reflection writings data from the teacher and students revealed that especially some disadvantaged students were more active during the activities and displayed their skills better.

Parallel Session - 1.28 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Kathleen Hill

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120 Research-Based Iterative Science Curriculum Development

Nana Quistgaard, Mikkel Bergqvist, Niels Matti Søndergaard

LIFE Fonden, Lyngby, Denmark

Abstract

We are evaluating a new 10-year educational program, whose goal is to strengthen children's and young people's scientific comprehension and interest in science and their choice of a career within science. The program iteratively develops teaching units based on science education research and school trials. It consists of an in-school activity box and access to state-of-the-art teaching labs for one-day follow-up events. In 2022, more than 60.000 students took part in a teaching unit, most of them in middle or lower secondary school. The teaching units are situated within socio-scientific issues using a guided inquiry-based approach. To ensure that units lead to the intended short and long-term outcomes, a research-based theory of change guides the development of teaching units with questions like: Is the socio-scientific issue relevant for the target group? Do the activities support student autonomy? Will aesthetic tools mediate cognition? Are argumentation activities operant? About fifteen months are spent on developing each unit. During this time an extensive research strategy based on formative evaluation of activities and unit progression assesses the efficacy of the teaching units. Evaluation criteria are derived from the theory of change. Desired short-term outcomes are

development of situational interest, knowledge, and competence. Examples of criteria are focused attention, persistence, self-efficacy, ability to describe inquiry-processes, analyze results and assess arguments. School trials indicate engaged student behavior and positive attitudes e.g. "It's a good initiative, and it's cool that they take the climate war to a local level". This finding is supported by user satisfaction surveys. Overall, teachers and students find the content of the units relevant and useful, and the teaching methods inspiring especially the many experiments, but there are also points of concern. Next, we will use quantitative and qualitative data to assess student impact.

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381 Student Learning Through Engaging With Contemporary Scientists' Practices in the Classroom

Mary Vamvakas

Deakin University, Melbourne, Victoria, Australia

Abstract

There is continuing policy interest for school science reform to re-engage students in science and equip the future workforce with the necessary science, technology, engineering, and mathematics (STEM) skills for innovation and future employment. Calls to action advocate for stronger connections between classrooms and scientists to engage students in science and develop their scientific literacy. However, the complexity in achieving these signals a need for viable and practical solutions to connect with scientists and their practices more strongly. My research explores how to effectively link students with scientists and their practices through a blended environment in ways that students learn what it feels like to do science and how scientists generate new knowledge. This research reports on a) a Web-based survey of science teachers probing their beliefs and practices regarding representation of contemporary science in their classroom and b) investigation of the learning affordance of online curriculum resources in the classroom. Survey findings identify that teachers are overwhelmingly positive about the need to represent contemporary science and multiple ways they do that, that don't, however, allow deeper connection, but also identify structural barriers resulting in low levels of this practice. Implementing design-based research methodology, I worked with teachers to modify, and refine online curriculum resources that forefront scientists' research and practices providing students with contextual, current, and contemporary science learning experiences. I will report on the trialling of resources and describe fresh understandings of how to productively represent scientists' contemporary research and practices in the classroom, the teaching opportunities and learning affordances of using the resources and the benefits of and challenges teachers experience in engaging their students in contemporary science practice in the classroom.

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796 Instructional Design Enriched With Sensory Technologies for Visually Impaired Students

Davut Sarıtaş[1], Zeynep Ağyan[2], Hasan Özcan[2]

[1]Nevşehir Hacı Bektaş Veli University, Nevşehir, Turkey. [2]Aksaray University, Aksaray, Turkey

Abstract

In Turkey, inclusive education is implemented at the primary, secondary, and high school levels. In this context, technological tools and applications are used for the adaptation and teaching of visually impaired students. In Turkey, although there are legal regulations for visually impaired students, it can be stated that there are insufficiencies in the use of information technologies and their use in education and daily life. In this context, teachers need more examples of applications and materials. This study aims to prepare science teaching materials enriched with technologies (STMET) that appeal to the senses of sound and touch for teaching the Earth and the Universe subject in the science course for visually impaired inclusive students and to evaluate their effectiveness. For the required instructional design, the widely used ADDIE model is utilized. In this context, the study is carried out with the Design-Based Research method as research method. A literature review was conducted and the study group was determined. The necessary ethics committee permission was obtained for the study. Draft outcomes were determined by taking into account the Science curriculum being implemented in Turkey. In this study, Tesseract and Adobe Acrobat, which have Turkish support and are free of charge, will be used among the instructional technologies used for the visually impaired. Google Drive OCR was determined as an alternative. It is expected that the study to be presented will provide results that contribute to the science education literature in terms of the education of visually impaired individuals and open the door to further studies. It is also hoped that the STMET to be developed will serve as an example for materials to be prepared in different subjects in science education.

1112 Examining Teachers' Perceptions of Authentic Science Practices and Practices-Based Curriculum

Kathleen Hill, Tiffany Lewis, Matthew Johnson

Pennsylvania State University, University Park, PA, USA

Abstract

The Next Generation Science Standards in the United States emphasize that teachers should teach science and engineering content by engaging students in the practices of experts. To develop practices-based curriculum, teachers must have sufficient knowledge of the practices of scientists and engineers (SEPs). Research experiences for teachers (RETs) in academic labs coupled with professional development is a strategy to increase teachers' understanding of these practices. This study focused on teachers' perceptions of SEPs as they engaged in research and how they prepared curriculum for students to investigate and ultimately explain a particular phenomenon or solve a problem. The findings indicate that RET programs can

successfully support teachers in building curriculum that engages students in the practices; however, these are limited to practices directly associated with own research. Teachers characterized activities as being authentic based primarily on student agency rather than engagement in the SEPs. More collaborations between STEM researchers and pedagogical experts are needed to bring authentic STEM learning experiences to precollege classrooms.

Parallel Session - 1.29 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Enja Osman

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433 Instruments for Diagnosing Students' Conceptions of Optical Phenomena

David Treagust, Marjan Zadnik

Curtin University, Perth, Western Australia, Australia

Abstract

Students' understanding of optical phenomena was an early topic of research interest and continues to be an important focus for physics education researchers world-wide. In this chapter, we review a wide range of studies with an emphasis on the different types of diagnostic instruments used to generate qualitative and quantitative data about understanding of age-appropriate optical phenomena at elementary, secondary, and university levels of schooling, including teacher education. Several studies implemented different teaching approaches and appraised them, often comparing findings of experimental and control groups. Researched topics include light propagation, shadow formation, reflection from mirrors, refraction of light by lenses, image formation, polarization, and photoelectric effect. Most of the reviewed studies identified students' conceptual difficulties and provided recommendations for future teaching and learning; fewer studies presented a radical change of curriculum based on research findings and evaluated student learning. We recommend that progress in learning optics can be made by curriculum designers considering the findings from optics research.

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740 Pedagogical factors affecting the translation of pedagogical content knowledge about electrostatics into practice

Ernest Mazibe

University of South Africa, Pretoria, Gauteng, South Africa

Abstract

Teaching practice internships provide opportunities for pre-service teachers (PSTs) to enact their knowledge in real classroom settings. This paper investigated PSTs' pedagogical content

knowledge (PCK) about electrostatics, its translation into practice and factors that affect the translation. The refined consensus model (RCM) of PCK served as theoretical framework. Data reflecting the PSTs' PCK was collected using content representations (CoRe) tools and lesson planning forms. Classroom observations were used to collect data reflecting their practice. Data was analysed deductively, using in-depth qualitative analysis to look for the manifestations of knowledge and skills related to (i) curricular saliency, (ii) learners' understanding of science, and (iii) conceptual teaching strategies including representations. In instances where the practice was different from the PCK, interview questions were formulated to elicit the pedagogical factors that affected the translation of the PCK into practice. The results revealed multiple instances where the PSTs were unable to translate their PCK into practice. The pedagogical factors that were identified were integrated, with some factors serving as triggers for others. The factors included interactions with learners, the involvement of mentor teachers, teacher efficacy, management of time for teaching concepts, and reflections. The results have implications for PST education and mentorship during teaching practice internships.

1183 Students Think Critically About Antimatter: Evaluation of the Effectivness of a Domain-Specific Critical Thinking Instruction

Farahnaz Sadidi, Gesche Pospiech

Technische Universität Dresden, Dresden, Free State of Saxony, Germany

Abstract

Teaching critical thinking (CT) is desirable in all school subjects and specifically in science. However, the lack of clear theory supported by empirical findings for developing lessons to promote CT, makes teaching CT challenging for teachers. Here, we present an antimatter course developed to teach CT to students of grades 10, 11, and 12. The course was implemented by physics teachers in 3 classes. The data was analyzed using the constant comparative method. Inductive analysis of the data showed that the antimatter course actively engaged students in the processes of applying content knowledge, applying CT skills, and developing disposition that correspond to a developed CT. This shows the effectiveness of the antimatter course in promoting students' CT and that the design principles of the antimatter course work well. The design principles of the antimatter can contribute to the theory of instructional design to help teachers to design effective lessons for promoting students' CT.

1062 Do Students Believe They Are Applying 21st Century Skills in Classroom Instruction?

Enja Osman[1], Hiba Hamdan[2]

[1]American University of Beirut, Beirut, Lebanon. [2]University of Cambridge, Cambridge, United Kingdom

Abstract

With the knowledge explosion and increasing demand of skills needed for the workforce and success in life, teachers are expected to equip their students with skills and competencies to confront future challenges and adapt to an era of globalization (e.g. Malik, 2018). Several studies researched teachers' perceptions on the extent to which 21st century skills are practiced in a school setting or embedded in school curricula (e.g. Martinez, 2022). However, this study explores students' views on the extent to which they practice 21st century skills during classroom instruction in general and science subjects in specific. A questionnaire capturing features of 21st century schools was adapted from Hixson, Ravitz & Whisman (2012) and administered to 944 secondary school students (Grades 11-12) from 23 public schools in all eight districts. Data was analysed using SPSS 21.0 to calculate frequencies and ANOVA. Results showed no homogeneity in practicing the 21st century skills and their associated practices across subjects. Moreover, students associated creativity and innovation skills with the use of technology in the form of ICT only, a major misconception that needs to be addressed. Importantly, although students' responses indicated a relatively high rate in applying creativity and innovation skills in science teaching, their application of collaboration, communication, local, and global connections skills were among the lowest in the sciences. Recommended actions is discussed in light of recent educational reform initiatives, curriculum policy and teacher professional development.

Parallel Session - 1.30 (Oral Presentations)

15:00 - 16:30 Monday, 28th August, 2023

Chair: Ingo Eilks

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95 The Representation of the Concept of Sustainability in Social Media

Nadja Belova[1], Tobias Grieser[2], Charline Harms[1]

[1]University of Bremen, Bremen, Germany. [2]University of Oldenburg, Oldenburg, Germany

Abstract

Nowadays, everyone can spread information through social media and the number of users of social networks is increasing worldwide. The information in such media often has a scientific background but does not necessarily have to be disseminated by experts, which has fundamentally changed the way of communicating and reflecting on scientific content. A frequently mentioned topic on social media is sustainability. Sustainability is a multidimensional concept – the common models include an ecological, a social as well as an economical dimension. However, an analysis of 200 posts on the popular social networks Instagram and TikTok showed that this multidimensionality is not reflected on social media; sustainability is mostly reduced to ecological aspects with the economical component being almost completely neglected. From this it can be concluded that people who inform themselves about

sustainability via social media get a very simplified and actually incorrect picture of it. In order to initiate reflection on this among learners, a teaching proposal is presented.

102 The Austrian ECOLOG Schools Network: Case Studies on Education for Sustainble Development

Franz Rauch[1], Mira Dulle[1], Markus Messerschmidt[1], James Loparics[2]

[1]University of Klagenfurt, Klagenfurt, Austria. [2]University of Linz, Linz, Austria

Abstract

ECOLOG is a programme and network for the greening of schools and education for sustainability in Austria. For 25 years over 690 ECOLOG schools and 13 colleges of teacher education have been integrating an ecological approach into their everyday school life and school development. Throughout the the ECOLOG-schools network's existence, a series of evaluations, inquiries, and studies have been produced (Rauch & Pfaffenwimmer, 2020). In this presentation we show the current accompanying research within the framework of ECOLOG which focuses on all-day schools. In four case studies at selected ECOLOG schools, the extent to which a whole-day organisation of school life including digital media can support ESD in the context of ECOLOG is investigated.

115 Sustainability Issues and Media in Education: A Case on Learning about Critical Resources in Chemistry Education

Ingo Eilks, Jana-Christin Bütow

University of Bremen, Bremen, Bremen, Germany

Abstract

Every developed economy is dependent on the supply of certain raw materials. However, some raw materials are rare as such or are only mined in selected countries. This can result in a supply risk. Economic important industrial resources with a supply risk are considered as critical raw materials. The European Union publishes a list of critical raw materials for the European economy every three years. The paper describes a digital learning scenario that enables learners to learn about the concept of criticality and critical raw materials. First lessons learned from lower and upper secondary chemistry education are presented.

Parallel Session - 2.1 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Julien-Pooya Weihs

928 Students' Difficulties in Understanding the Meaning of Measurement Units

Guy Raviv, Shulamit Kapon

Technion – Israel Institute of Technology, Haifa, Israel

Abstract

Measurement units are an essential part of mathematical modeling, since they attribute real-world meaning to the numerical values of variables and parameters in mathematical models of real-world phenomena. This paper presents an analysis of students' responses to a diagnostic question that aimed to uncover different facets of understanding of the meaning of measurement units and how these facets are manifested in the process of mathematical modeling in physics. The participants were 9th grade students (N=463) enrolled in a Massive Open Online Course in kinematics. The analysis illustrates how students' difficulties in understanding the meaning of compound units (units that are result from the multiplication or division of more basic units) hinder proficient engagement in mathematical modeling.

765 Just Play It! Factors That Support Learning in Videos on Physics

Tanja Mutschler[1], David Buschhüter[1], Christoph Kulgemeyer[2]

[1]University of Potsdam, Potsdam, Germany. [2]University of Bremen, Bremen, Germany

Abstract

Learning videos on understanding complex principles of physics have become popular among students. Yet, these videos differ in quality and sometimes even reinforce learners' preconceptions. To understand the interplay of various conditioning factors for learning success like motivation, interest, or perceived structuring within this popular medium we designed a video based learning unit on Newton's law of interaction that follows both quality criteria for explanatory videos and adjoining didactic and multimedia aspects for learning. The unit was embedded in a pre-post-test setting eliciting the constructs motivation, interest, perceived structuring and content knowledge. For an initial analysis, data were available from N=157 high school students. Our results show a statistically significant correlation with learning success for the constructs effort, interest in physics, and perceived structuring. No gender differences were found in terms of learning success but in self-perceived competence. Overall, however, the measured learning success lies only slightly above the expected value of randomly selected answers indicating that learners' preconceptions remain stable. Based on these results, conclusions for designing learning videos are discussed.

544 Language, Coherence and Children's Conceptions of Force

Dina Masri[1], Tamer Amin[2]

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Abstract

This study engages with the debate on the degree of coherence of learner's pre-instruction conceptions, focusing on the concept of force, specifically. In studies conducted in different contexts around the world, young children, in particular, have exhibited very different degrees of coherence in their conceptions of force. In this paper, we offer a theoretical framework that predicts that language is a population variable that could explain some of these differences and test this hypothesis by investigating the conceptions of force of children (7-12 years of age; N=185) with three different language profiles in the Kingdom of Saudi Arabia: monolingual in Arabic; monolingual in English; and bilingual in Arabic and English. We used the structured interview developed by Ioannides and Vosniadou (2002) and used by other researchers in order to compare our results with the results of studies conducted in different linguistic contexts. The results supported our hypothesis: significantly more Arabic monolinguals exhibited coherence than English monolinguals, with an intermediate proportion of bilingual children exhibiting coherence. We discuss our results in relation to those reported in previous studies and examine how our theoretical framework relates to other theoretical perspectives on science concept learning. Finally, we point out the novel pedagogical implications of our perspective and findings.

1182 Identifying Troublesome and Potentially Threshold Concepts in Cloud Microphysics

Julien-Pooya Weihs[1,2,3], Elias Euler[4], Vegard Gjerde[1], Helge Drange[1,2]

[1]University of Bergen, Bergen, Norway. [2]Bjerknes Centre for Climate Research, Bergen, Norway. [3]Centre for Integrated Earth Science Education, Bergen, Norway. [4]Colorado School of Mines, Golden, Colorado, USA

Abstract

Geoscience education has gained significant attention in recent years as a way to understand student difficulties with often counter-intuitive, complex and theoretical concepts describing the Earth sytem. Cloud physics as a subdiscipline of geoscience is key for understanding weather and climate. Research on cloud physics education has, however, been limited. Here we investigate the difficulties faced by undergraduate students during a four-hour cloud microphysics lecture and aim to identify troublesome concepts. An open-ended survey was conducted after the lecture. Twenty-nine students answered five questions related to the concepts they were taught. Thematic analysis was used to code, categorize and filter the data, resulting in a list of concepts related to the course content and their total counts from the survey. The analysis reveals that four properties could be extracted from the data: identifiability,

novelty, troublesomeness, and importance. These properties are subsequently used to discuss potential threshold concepts in cloud microphysics. We also discuss the criticism that threshold concept theory is exposed to and motivate the necessity to develop a working definition of threshold concepts with a reduced set of properties that could uphold the discussion around their identification. Based on the results of the survey and a review of their geophysical ontology, we find that "Homogeneous and heterogeneous nucleation" and "Critical radius of a droplet" are prime threshold concept candidates. This study highlights the importance of considering the students' perspectives and difficulties when investigating the nature of concepts in a specific discipline. It provides valuable insights into the field of cloud physics education and may inform the development of instructional materials and teaching practices. The developed methodology can be applied to any other disciplinary topics.

Parallel Session - 2.2 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Seamus Delaney

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447 Do Pre-Service Teachers and Teachers Recognize ESD-Specific Competencies in Chemistry Textbooks - a Task Analysis

Katharina Forster, Jenna Koenen

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Abstract

Creating a sustainable future is becoming increasingly important, which is why the integration of sustainability into education is being called for within the framework of education for sustainable development (ESD). In the school context, textbooks can play a supporting role in teaching ESD-specific competencies and sustainable topics. However, the full potential of these can only be revealed if teachers are able of recognizing the specific ESD aspects in textbooks and in particular in assignments. The aim of the present study therefore, is to determine the extent to which (pre-service) teachers can identify ESD-specific competencies and sustainable topics in assignments. For this purpose, pre-service teachers and teachers majoring in chemistry were asked to analyze tasks with regard to ESD-specific as well as general competencies in the form of a questionnaire using the method of thinking aloud. The results of the pilot testing show that the developed instruments are able to reveal (pre-service) teacher competencies in ESD. In addition, first results indicate a low level of knowledge about the concept of ESD as well as considerable difficulty in identifying competencies.

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204 Promoting Secondary Students' Understanding of Sustainability Issues in Science Education by Utilizing Actor-Network Maps in the Frame of Research-Informed Action Projects

Dimitris Tsoubaris, Georgia Liarakou, Evgenia Flogaiti

National and Kapodistrian University of Athens, Athens, Greece

Abstract

Sustainability issues of our time, such as global warming, are often closely linked to developments in the fields of Science and Technology and particularly the ways powerful groups influence them to better serve for-profit purposes. We advocate that science education can potentially play a notable role in facilitating the equitable resolution of such problems by incorporating aspects of Environmental and Sustainability Education, thus promoting young citizens' awareness, critical thinking skills and action competence. This paper reports on the findings of an Action Research that took place in the frame of an early secondary Science class at an independent British school. The research investigated the outcomes of a teaching strategy that systematises the processing of Research-informed Action (RiA) projects on socio-scientific issues. Through the first cycles of Action Research, students were exposed to a variety of RiA preparation activities relating to the Chemistry unit "Combustion" and the Biology unit "Breathing and Respiration". The aim of these activities was to facilitate students' understanding of sustainability, as a concept that links to the Key Stage 3 Science curriculum, in addition to supporting the development of relevant research skills and attitudes. During the last cycle of the research process, students conducted a RiA project on sustainability issues of their own choice. The process and outcomes of this project work are discussed. Evidence suggests that students were encouraged to recognise interrelationships of living, non-lining and semiotic actants of sustainability issues, as well as to identify alliances of actants with different interests. In this context, we particularly focus on outlining a key strategy, which is an adaptation of Actor-Network Theory in the context of sustainability. The strategy involves utilising ANT maps as analytical tools of socio-scientific issues in the frame of the dimensions of sustainability.

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151 A Case Study on Learning about Plastics Use for Secondary Chemistry Education Connected to Confucian Ecological Ethics

Baoyu Li, Ingo Eilks

IDN-Chemistry Education, University of Bremen, Bremen, Germany

Abstract

The use of plastics is a global controversial issue. In recent years, many countries employed various strategies to reduce plastics use and production. In this teaching intervention, single-used plastic take-out food containers are focused as a socio-scientific issue (SSI) for secondary chemistry education in mainland China. In the lesson plan, learning about responsible use of plastics is linked with Confucian ecological ethics. The intervention contains an introduction, learning about the content behind the SSI, and a role-play debate for raising students'

awareness of environmentally friendly attitudes and behaviors. It took place to learn about a potential contribution of Confucian ecological ethics to science education for sustainable development, underscoring the cultural aspects of scientific literacy. The lesson plan was designed, implemented, and evaluated in a suburban high school in Beijing, China. Two learning groups (N=74) joined the intervention. A feedback questionnaire indicates that reference to Confucian ecological ethics can make an innovative contribution to chemistry education for sustainable development in Confucian societies.

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138 Chemistry Teachers Addressing Critical Challenges Facing Society in the Classroom with Systems Thinking

Seamus Delaney[1], Madeleine Schultz[2]

[1]School of Education, Deakin University, Burwood, Victoria, Australia. [2]School of Life and Environmental Sciences, Deakin University, Waurn Ponds, Victoria, Australia

Abstract

Re-positioning the public image of chemistry, which is one of the stated goals of an ongoing international, systems thinking-oriented collaboration of chemistry education researchers, involves also re-positioning chemistry curricula and the teachers who teach them. Systems thinking positions students (and their educators) to identify the economic, social and environmental aspects as well as the cultural heritage that has impacted the formation of the science that they learn in the classroom, and to describe the relationships between these different levels, in order to better understand the complex real-world contexts and critical challenges (such as those related to the United Nations Global Goals for Sustainable Development) that are making their futures uncertain. In Australia, in an ongoing project, an interdisciplinary team of science and social science researchers have collaborated to implement and evaluate approaches that incorporate systems thinking and situate sustainable development within chemistry education at secondary and tertiary levels. These efforts are aligned with the increased inclusion (though still underrepresented) of green and sustainable chemistry content in mandated state and national science curricula worldwide. This presentation explores the outcomes of a recently implemented systems thinking-oriented professional learning program, through activity responses collected from students and teachers and semi-structured interviews with the teachers. The program supported secondary chemistry teachers to integrate systems thinking and socio-scientific issues such as climate change and sustainable development into their chemistry classroom.

Parallel Session - 2.3 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Michael Giamellaro

92 Difficulties Faced by Multilingual Learners when Reading Science Text: The Impact of Intertextuality

Saouma BouJaoude[1], Sara Salloum[2]

[1]American University of Beirut, Beirut, Lebanon. [2]Ohio University, Athens, Ohio, USA

Abstract

The purpose of this study was to use intertextuality as a lens to describe the experiences of COUNTRY'S multilingual learners with reading to learn science and examine factors that make textbook reading challenging. Specifically, the following questions were explored 1) Are intertextual links clear for students to make when reading text among different forms of texts/semiotic resources? 2) Are intertextual connections to everyday life made by students? And 3) What particular words/terms and sentences do students identify as difficult? And what are the features of those? The study reported here is the first stage of a larger ongoing study. This first stage involved giving Grade 8 students a selection from the official life science textbook to comment on individually. Stage 1 data were collected from 104 Grade 8 students in three public schools in which the language of science instruction is English. However, the results of 54 students in two schools are reported in this proposal. A framework including intertextuality categories was used for data analysis. Findings indicate that COUNTRY'S textbooks display serious issues in three intertextuality categories: Links among written and visual text, connections between students' experiences and lives, and students' processing and appropriating science discourse and language.

94 Use of Analogies in the Teaching of Science-Post-Festum and Heuristic Analogies

Dr Nikolaos Fotou

University of Lincoln, College of Social Sciences, School of Education, Lincoln, Lincolnshire, United Kingdom

Abstract

Research on science education has evidenced the function of analogies as a didactic tool that, when appropriately and effectively used, has the potential to facilitate the learning of abstract concepts. This paper summarises research on the use of analogies in science teaching while switching attention to the use of analogies generated by students in the process of science learning. It also discusses the heuristic use of student-generated analogies in approaching and understanding what was previously unknown. Such a heuristic use of analogies derives from research with 10 to 17-year-olds, who, when asked to make predictions in a number of unknown situations and to then provide explanations about these predictions, generated analogies and reasoned on their basis to understand what was previously unknown and unfamiliar. The paper argues that such a heuristic use of analogies can be used in science teaching in revealing how students approach situations they have not considered before on the one hand and the sources

they draw upon in doing so on the other.

183 The Role of Context when Using Art to Introduce Primary Students to Human Senses

Zülfiye Melis Demir[1], Per-Olof Wickman[2]

[1]Eskişehir Osmangazi University, Eskişehir, Turkey. [2]Stockholm University, Stockholm, Sweden

Abstract

This research aims to examine how student interactions with painted portraits and their contexts support the transduction from images to shared spoken discourse in class. We asked "What various spoken meanings about sense organs do the context of portraits elicit from students in class?" and "How do the interactions with the teacher and the various contexts of the paintings influence the meanings made?". The introduction on the sense organs was part of a design-based teaching unit integrating art and science in a Turkish primary school at grade three. The whole course encompassed eight lessons during four weeks. Lessons were video-recorded. A verbatim transcript of recordings was made. The aims of the introduction analyzed here were for the students to (1) realize the importance of sense organs, and (2) explain the basic function of the sense organs. In the analysis we adopted practical epistemology analysis, which permitted us to examine how students' encounters with the teacher and the portraits helped the students to notice certain gaps concerning the aims and the relations they filled these gaps with to attain the aims. Our results show how the contexts offered by art and portraits are helpful in making children to go beyond general statements about our sense organs. One painting, just representing a person against a neutral background, did not mediate more situated comments. In the three other paintings, including a brush and palette, a landscape and a garden, respectively, played important roles for what relations students established. Also the teacher situating the more general questions of the aims in the context of each painting was important to assist students in understanding the more general questions and filling these gaps with relevant relations.

264 Describing the Landscape of Contextualized Science Learning: A Bibliometric Network Analysis

Michael Giamellaro[1], Cory Buxton[2], Joseph Taylor[3], Jean-Philippe Ayotte-Beaudet[4], Kassandra L'Heureux[4], Marie-Claude Beaudry[4], Talal Alajmi[2]

[1]Oregon State University, Bend, OR, USA. [2]Oregon State University, Corvallis, OR, USA. [3]University of Colorado, Colorado Springs, CO, USA. [4]Université de Sherbrooke, Sherbrooke, QC, Canada

Abstract

Citation patterns within an academic field (bibliometrics) can indicate the semantic landscape and identify the research front of that field. This method is valuable for large samples of documents for which a narrative review is not realistic and for understanding educational

constructs that have evolved within distinct but parallel research trajectories. Such is the case of contextualization in science education. This study is a bibliometric landscape review of contextualized science learning in which 13 clusters of thought were identified and characterized. The analytic process also identified the relationships between the clusters of thought and indicated how these clusters can inform each other to drive future research and practice.

Parallel Session - 2.4 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Catarina Martins Bianchi

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219 Assessment of Conceptual Understanding in Physics and Conceptual Tests

Derya Kaltakci-Gurel

Kocaeli University, Kocaeli, Turkey

Abstract

Assessment is a process for determining the nature and extend of student learning and development. It helps us understand what students bring to class before instruction, how well they met the learning objectives after instruction, which parts of the curriculum and instruction are effective and which are not, and what unique problems our students face. In Physics Education Research (PER), research-based, research-validated conceptual assessment is crucial. Therefore, in the PER to assess conceptual understanding many different tools have been developed and used. Among them interviews, open-ended tests, and multiple-choice conceptual tests (which are usually called 'inventories') are found to be the ones commonly used in the PER to assess conceptual understanding. In this symposium the advantages and disadvantages of each tool and the conceptual tests are discussed in detail.

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425 "We Clicked Right Away" – a Digital Learning Environment for Collaboration to Observe and Foster Conceptional Reconstruction

Malte Michelsen, Jorge Groß

Philipps-Universität, Marburg, Hessen, Germany

Abstract

Dealing with student conceptions is a central element of student-oriented teaching - everyone agrees on that. However, the implications for classroom design have not yet been fully elucidated. First approaches, such as the conceptual change theory, have over the years been supplemented by a variety of affective and motivational factors. Little is known about the mechanism linking these factors. This qualitative study aims to shed light on the process of

conceptual reconstruction. Therefore, learners were given an assignment on the topic of plant nutrition and the task of collaborating to develop a jointly supported solution. In order to study changes in conceptions, the Peer-Interaction-Method (PIM) was used. It requires that only learners with different conceptions work together in order to cause a content related conflict. The expressions of the participants were examined from the perspective of the conceptual metaphor theory – a cognitive linguistic theory of understanding. The results show an unexpected result: the anticipated content-related conflicts do not have to occur in order to reach a jointly supported solution. Instead, we can show that a social conflict shapes the development of the collaboration process. Furthermore, the peer interaction method turns out to be a constructive and fruitful way of dealing with subject-specific heterogeneity in conceptions. To provide the necessary infrastructure for the matching of learners with different conceptions in the school context, we have developed a digital plug-in for moodle e-learning platforms. It not only allows the peer interaction method to be applied in a classic 45-minute time frame, but also offers opportunities for collaboration between research institutions and schools.

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752 Complexity: A Proposal for Learning About Environmental Impacts

Beatriz Penha Scarabotto, Catarina Martins Bianchi, Victor Hugo Rosa Romanato, Magda Medhat Pechliye

Universidade Presbiteriana Mackenzie (UPM), São Paulo, SP, Brazil

Abstract

Lesson proposal presented in a degree course in Biological Sciences. The class consists of a detective game in which each student is suspected of having killed an indigenous youth. During the game, each student must raise hypotheses, accusing the others, about who was responsible for the murder. Once this is done, the outcome is presented and the boy's death is related to the anti-ecological actions of all the characters, which led the students to develop a systemic and political view of environmental impacts.

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231 "I have a Map in my Mind": Assessing the Elementary Students' Science Understanding with Concept Maps

Yizhe Chen, Xiaomei Yan

School of Education, Shanghai Jiao Tong University, Shanghai, China

Abstract

While K-12 students' understanding of core concepts in science education has gotten more attention, the effective and efficient assessment remains challenging. The concept map as a visual tool to explicitly present the multilevel concepts and highlight the relations between concepts is a promising evaluation tool. This study explored the applicability of concept maps at the primary level with four students in China. The participants constructed concept maps of what they learned from one short science video course. The individual interviews were

conducted for verification of their concept maps. The propositions from concept maps and interview transcripts were extracted by MAXQDA Analytics Pro 2020 software. The finding suggested that the participants had difficulty constructing complete concept maps, especially with linking phrases. Compared with interview results, concept maps presented correct concept propositions fewer in quantity and lower in the abstract hierarchy. It was indicated that the participants had difficulties using concept maps to present their comprehensive understanding of core science concepts. Thus, using concept maps solely to evaluate elementary students' understanding of science concepts might not be sufficient. The rich and detailed understanding in interviews suggested that combining interviews and concept maps might be an effective way to evaluate elementary students' science conceptual understanding. The findings also inspire further studies on whether concept maps are more cognitively demanding for elementary students than verbal explanations for expressing their understanding of the science core concepts.

Parallel Session - 2.5 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Rikke Frøhlich Hougaard

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813 Impacts of Project-Based Instruction on Students' Epistemologies about Physics and Learning Physics

May Lee[1], Cormac Larkin[2], Steven Hoekstra[1]

[1]University of Groningen, Groningen, Netherlands. [2]University of Heidelberg, Heidelberg, Germany

Abstract

The preparation of students to address future STEM-based challenges requires 21st-century skills. These skills are mediated by their epistemologies about science (i.e., beliefs on the nature of scientific knowledge and knowing). One instructional approach shown to support students' development of epistemologies is problem-based instruction (PBI), which we implemented in a physics course at a Dutch university. We used a mixed methods qualitative approach to examine how the implementation affected students' beliefs about physics and learning physics. Our analysis of the course surveys during the first implementation showed that students identified key challenges (e.g., access to equipment, collaboration with peers) with the implementation but expressed positive general experiences. In the second PBI implementation, students' responses to a validated survey about physics epistemologies showed a shift towards being more expert-like beliefs except for the prompts related to sensemaking/effort. These findings can inform teachers interested in supporting students' development of physics epistemology and implementation of PBI in undergraduate STEM

courses.

924 Navigating the STEM University Transition: Effects of a Combined Mindset and Learning Strategy Online Intervention

Malte Diederich[1], Verena Spatz[1], Thomas Wilhelm[2], Jana Rehberg[2]

[1]Technical University of Darmstadt, Darmstadt, Germany. [2]Goethe Universität Frankfurt, Frankfurt, Germany

Abstract

Mindsets (implicit theories) can have a great impact on learning and play a particularly important role when facing challenges such as transition from school to university. This study looks at the effect of a single online intervention on students' motivation and intentions to change majors or drop out. The intervention combines a mindset message with learning strategies adapted to the university STEM context in a symbiotic way. With a questionnaire survey (T1 at the start of the semester, T2 two months later), domain-general mindset, domain-specific mindset and domain specific academic self-concept are measured for an intervention group (IG, n=89) and a control group (CG, n=278). Results suggest a positive impact of the intervention on mindset and self-concept. Regarding intentions to change majors or drop out (measured only at T2), we report in general low intentions among the participants. Only a subgroup that reported continuous struggle during the semester showed higher intentions, which were lower amongst the students who participated in the intervention.

1195 Enhancing STEM Teaching in Higher Education: A Study of Project-Based Pedagogical Development for Novice Teaching Assistants

Rikke Frøhlich Hougaard, Karen Louise Møller

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Abstract

Growing demands for STEM teaching in higher education to adopt evidence-based pedagogical practices highlight the importance of professional development for STEM teachers. Research on previous efforts has shown that it is not simple to support teachers in adopting new pedagogical evidence in own practice. This study reports on the development and implementation of a pedagogical course designed for Ph.D.-students serving as teaching assistants in STEM higher education. The course was designed as project-based learning where participants work with small-scale projects in own teaching plays and use input from teachers and collaboration with peers to support reflections and professional growth. Data collection includes both quantitative and qualitative data from pre- and post-course questionnaires, thematic analysis of project reports, and semi-structured interviews with course participant. The paper aims at widening our insight into the challenges and desires for professional growth experienced by novice teaching assistants, and investigate the aims, learning outcomes and meaning-making related to working with a small-scale development project in own

teaching. The findings will be discussed in relation to sustainable adaptation of evidence-based pedagogical practices in STEM higher education.

Parallel Session - 2.6 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Joseph Krajcik

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449 Stimulating Reflection Processes with an Eye-Gaze-Augmented Retrospective in Organic Chemistry

Axel Langner, Nicole Graulich

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Abstract

Understanding complex representations and the respective implicit content they convey is a crucial skill in a scientist's professional development, *i.e.*, of an organic chemist. Although various studies indicate that students often struggle to derive implicit information from organic chemical representations, there is a lack of instructions to foster students' comprehension of such complex representations individually. In the epistemology of practice, new knowledge and understanding can be achieved by reflecting on one's implicit professional knowledge in patterns of action and feelings while doing this action. In this regard, eye tracking may support these reflection processes by providing insights into information inaccessible to a learner. However, the potential of such an eye-gaze-augmented retrospective to stimulate reflection has not yet been investigated. Therefore, a qualitative, exploratory study has been conducted to characterize students' reflection processes while watching their own eye-gaze replay in a semi-structured retrospective interview. Results show that eye-gaze-augmentation offers new possibilities for reflection. However, the nature of the reflection process depends on the learners' success during the problem-solving. In conclusion, an eye-gaze-augmented retrospective interview can be used as a tool to stimulate reflection, but further optimizations are necessary to engage students in deeper reflection processes.

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639 Drivers of Pre-Servıce Science Teachers' Intentions to Use Coding in STEM Education

Kibar Sungur Gül

Nevşehir Hacı Bektaş Veli University, Nevşehir, Turkey

Abstract

This study aims to examine pre-service science teachers' intentions to use coding in STEM education. The study defined the reliability and validity of the Coding Based-STEM Intention

Scale (CB-STEMIS) in the Technology Acceptance Model (TAM) framework with 133 pre-service science teachers in Turkey. The study's results revealed that the proposed model predicted 44% of the variance in the intention to use coding in STEM education. Findings also revealed that perceived ease of use and perceived usefulness have a positive effect on pre-service science teachers' attitude; perceived ease of use has a significant impact on perceived usefulness and finally perceived usefulness and attitude have an influence on the intention to use the coding-based STEM education. The study has important implications for education stakeholders to enrich STEM education with coding training.

916 Using Artificial Intelligence to Support Teachers' Use of Instructional Supports to Improve Students' Useable Knowledge: A Conceptual Framework

Joseph Krajcik[1], Peng He[1], Namsoo Shin[1], Xiaoming Zhai[2]

[1]Michigan State University, East Lansing, MI, USA. [2]University of Georgia, Athens, Georgia, USA

Abstract

Artificial intelligence (AI), such as machine learning, is widely used to score student responses to performance-based assessment tasks and to generate a dashboard to display the information on student performance. However, with such innovative technologies, teachers use assessment data in classrooms to make timely instructional decisions is challenging, especially with knowledge-in-use assessment tasks. This study articulates a conceptual framework to guide teachers' use of AI-based classroom assessment to improve their instructional decisions. The framework consists of four stages: access to the AI system through professional learning support, review of the automatic report dashboard, receiving AI-recommended instructional strategies, and making instructional decisions. Finally, we will present the findings from our study.

939 Exploring the Educational Potential of CHATGPT: Results From the FCI Test.

Agostinho Serrano de Andrade Neto[1], Bruno Campello de Souza[2], Juliana Anjos[1]

[1]Universidade Luterana do Brasil, Canoas, RS, Brazil. [2]Universidade Federal de Pernambuco, Recife, PE, Brazil

Abstract

The emergence of CHATGPT has been met with both excitement and concern, as the language model built by OpenAI has shown remarkable capabilities in a range of tasks. Studies have revealed that CHATGPT has the ability to write credible abstracts, score at C+ to B- levels in graduate exams, and even pass all three exams of the USMLE without specialized training. The Cognitive Mediation Networks Theory explains the impact of digital technologies on human thinking, with CHATGPT being an example of external processing tool that could potentially enhance student's information processing capabilities. The Force Concept Inventory was used to test CHATGPT's ability to answer physics questions and the results showed that CHATGPT

provided some correct answers or explanations for its reasoning and some alternative conceptions. Therefore, using CHATGPT in physics classroom must be done with care not to perpetuate – or even induce – alternative conceptions.

Parallel Session - 2.7 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Lilach Ayali

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628 Design and Implementation of Modeling-Oriented Learning Activities: How Do Science Teachers Favor Productive Modeling Processes?

Ainoa Marzabal[1], Luigi Cuellar[2], Valeria Cabello[1], Alba Cortés[1]

[1]Pontificia Universidad Católica de Chile, Santiago, Región Metropolitana, Chile. [2]Universidad Católica de la Santísima Concepción, Concepción, Región del Bio Bio, Chile

Abstract

Modeling-oriented approaches are emerging as promising strategies in science teaching. However, modeling-based science education experiences are still scarce, due to the difficulties of teachers in implementing learning activities that favor modeling processes. In this qualitative case-study we identified the activities implemented by 6 chemistry teachers at school level, evaluating the modeling potential of the activities. Also, we characterized the teachers' pedagogical responses that favor productive classroom discussions. The findings of this research are associated with three key aspects for productive modeling processes: the scientific school model, the modeling potential of the learning activities designed, and the teacher's actions to engage students in modeling processes. The productive modeling processes were rare in the observed science classes. The biggest obstacles for teachers to design and implement modeling-oriented learning activities seem to be the contextualization of the activities in everyday life and socio-scientific issues, and the management of dialogic productive discussion in the class to scaffold the processes of generating, expressing, applying, or evaluating students' initial models. Even though the results may not seem encouraging, we have found some episodes that show how fruitful productive modeling processes can be. We are convinced that continue working with practicing science teachers in the design and implementation of modeling-oriented learning activities will allow us to build better understandings of productive modeling processes, which in turn will inform teaching practices.

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631 A Framework for Implementing Computational Thinking Chemistry Instruction

Norhaslinda Abdul Samad[1], Kamisah Osman[1], Nazrul Anuar Nayan[2]

[1]Faculty of Education, National University of Malaysia, Bangi, Selangor, Malaysia. [2]Faculty of Engineering and Built Environment, National University of Malaysia, Bangi, Selangor, Malaysia

Abstract

The current workforces are facing 4th Industrial revolution with computer-based technology that required innovation in the global industry. Therefore, student need to be equipped with knowledge and necessary skill required such as computational thinking. The objective of this framework is to propose inquiry-based instructional approach that integrates the computational thinking concept in chemistry learning. This approach focuses on the utilisation of learning activities, such as unplugged and plugged in computational thinking, to integrate Chemistry knowledge into lessons and support students in developing key competencies through engineering design processes. Based on previous research, the integration of computational thinking in difficult subject such as chemistry can enhance student performance and instil the computational thinking skill. This study is intended to serve as a resource for chemistry instructors designing and conducting engineering-oriented lessons in secondary school classrooms, thereby enhancing students' understanding of chemistry. The computational thinking skills involved are decomposition, pattern recognition, abstraction and algorithmic thinking. Based on this approach, CThink4CS^2 Module which is based on computational thinking is developed. This paper discusses the conceptual framework for CThink4CS^2 Module and explanation on the learning activity that has been designed for form four Salt topic.

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637 Co-Design of a Model-Based Teaching and Learning Sequence for Technical and Vocational Education

Brant Miller[1], Cristian Merino[2], Catalina Iturbe-Sarunic[3], Ainoa Marzábal[4], Mailing Rivera[5], Francisco López-Cortés[6], Ximena Carrasco[7], Marjorie Ibacache[8]

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Abstract

Co-design is gaining momentum. Teachers more often participate as curriculum co-designers because this process can positively affect their professional development and generate resources that are relevant and useful for their own teaching practice and for their students'

learning. Co-design has the potential to develop more coherent guidance and more equitable learning opportunities for students, especially in the Technical and Vocational Education (TVE) sector. One of the needs for science learning communities is to democratize innovation and to sustain specific programs and interventions in the development of STEM capacities to design and probe solutions to problems that emerge in the teaching practice. In this communication we will discuss a Teaching and Learning Sequence's co-design experience with immersive technologies for TVE, through a Design-Based Research in Science Education (DBRiSE) approach.

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718 Mathematical Modelling in Physics Education: A Qualitative Meta-Analysis

Lilach Ayali, Shulamit Kapon

Technion – Israel Institute of Technology, Haifa, Israel

Abstract

Mathematical modelling - the process of using mathematics to represent and explore problems and phenomena in the real world - is an important epistemic practice in science. The physics education literature has conceptualized the role and practice of mathematical modelling in various ways over the years. We present results from a qualitative meta-analysis of 107 peer-reviewed papers on mathematical modelling in physics education published between 2000 and 2022. The qualitative meta-analysis articulates 6 educational goals for incorporating mathematical modelling in the instruction of physics, and 14 activities that operationalize this incorporation. The distributions of these goals and activities suggest that the use of mathematical modelling in the instruction of physics has been influenced by dominant educational approaches that focus on the 'learning of science' rather than 'learning to do science' and engaging students in epistemic practices.

Parallel Session - 2.8 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Ragnhild Lyngved Staberg

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480 Three Metafunctions of Language as an Instructional Framework When Guiding Drawing Explanatory Scientific Diagrams

Joonhyeong Park

National Institute of Education, Nanyang Technological University, Singapore

Abstract

The purpose of this study is to explore three metafunctions of languages in systemic functional linguistics (SFL) as an instructional framework for employing a draw-to-learn approach for constructing scientific explanations in science classrooms. The merits of drawing diagrams for learning have been increasingly reported in science education research in terms of engagement, reasoning, communication and assessment. One consensus in this research area is that teachers should provide sufficient guides in employing this approach in science classrooms. However, there remains a lack of understanding about illustrating the instructional framework or teachers' conceptualisations for guiding students about what and how to draw during their activities. Guided by the metafunctions (i.e., ideational, interpersonal and textual), I analysed a case of one teacher's teaching practices of employing drawing-diagram activities for explanation constructions in a general science classroom. I found that the teacher translated the objects to draw from the macro to the micro level, and from the verbal, or material, to the visual mode of representations for the students (ideational). To provide a clearer understanding of the roles of diagrams, she had reflective discussions with the students about how other people could interpret their diagrams and what would be important to represent iteratively through sharing the diagrams using a visualiser (interpersonal). She also often provided several examples of organising diagrams at the beginning of or during the activities to brainstorm ideas for the compositions (textual). This practical knowledge framed by the metafunctions of language will provide a better understanding of how teachers can deploy a draw-to-learn approach and intervene during drawing activities to facilitate students' science learning in general science classrooms.

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547 Guided Inquiry in Senior Secondary Biology: A Design Based Study With Teachers as Co-Researchers

Amrita Kamath, Peta White

Deakin University, Melbourne, Victoria, Australia

Abstract

Guided Inquiry (GI) is extensively endorsed in primary and lower secondary curricula in Australia, but evidently underutilized in senior science education where teacher-centric approaches appear predominant. In this design based study, five year-11 teachers at four schools in Victoria participated as co-researchers, collaborating with the researcher to implement contextually modified guided inquiry based educational interventions aimed to investigate the effect on student learning and engagement in senior biology. A researcher designed lesson sequence was collaboratively adapted and implemented by the teachers with their respective cohorts, progressively factoring in contextual influences through interactions between teachers, researcher, and students. Data was collected using varied methods including teacher & student interviews, field observations, artefacts, and classroom recordings. Underlying reasons for teachers' pedagogical decisions, and contextual factors encompassing cultural, technical and political influences were critically examined through thematic narrative

analysis. Three key findings emerged across the participating schools. 1) GI based approaches proved effective in enhancing engagement and learning overall, and showed significant positive impact for students who were typically disinterested/underperforming. 2) Teacher motivation emerged as crucial, with direct correlation to students' attitude towards GI, and performance in biology 3) School culture impacted enactment, with time constraint of senior secondary and student absenteeism being main factors impacting implementation. This DBR adds to the scholarly conversation aimed to identify and develop GI based pedagogical strategies, lesson design, and monitoring and assessment practices at senior secondary level. There is the potential for significantly improved outcomes and transformative teaching and learning agendas to be developed in conjunction with teachers, to provide evidence based advice to schools concerning possible modifications to pedagogical practice to focus on guided inquiry.

563 Learning Faraday's Law With Multiple External Representations in High School

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Abstract

Multiple external representations (MERs) are often used to teach complex topics in physics such as electromagnetic induction. An open question is whether there is an optimal way of sequencing MERs. On one hand, the so-called concreteness fading approach suggests that instruction should start with more concrete representations and proceed stepwise to more idealized ones. The effectiveness of this fading approach is however supported mainly from studies in mathematics education, while the results in physics are mixed. On the other hand, presenting different representations simultaneously may support linking the representations, which may benefit learning. In an experimental classroom study (N = 187), we compared concreteness fading (CF) and simultaneous presentation (SIM) of MERs for learning Faraday's law in high school. Both approaches were equally effective. The results align with previous studies questioning the superiority of CF compared to other ways of sequencing MERs. The results imply that there are different ways to effectively sequence MERs when learning Faraday's law. We discuss the implications for future research.

897 Critical Thinking in Science Education

Ragnhild Lyngved Staberg[1], Eldri Scheie[2], Håkon Johan Sævik[3], Eli Munkebye[1]

[1]Norwegian university of science and technology, Trondheim, Norway. [2]The Norwegian Centre for Science Education (Naturfagsenteret), Oslo, Norway. [3]Ris lower secondary school, Oslo, Norway

Abstract

This study is a literature review of peer-reviewed empirical studies from 1994 to 2022 regarding critical thinking (CT) in sciences education. The purpose of the review is to showcase and establish knowledge about empirical research on CT in primary- and lower secondary school science education, and contribute with an overview of approaches for researchers, teacher educators, and teachers on how science education develop students' CT competences. A total of 20 studies met the inclusion criteria and were included in the review. Based on a thematic analysis of the studies, including coding and categorization strategies, 11 main approaches were identified, in which inquiry-based, argumentation-based and problem-based were the most prominent. The approaches involved skills and dispositions that promote students' CT competences, e.g., asking questions, make and test hypothesis, analyze, explain, reflect, interpret, evaluate, draw conclusions. Authenticity and interdisciplinary learning, dialog, debate, and argumentation were promoted in ten studies. Group work and group discussions were also highlighted. When examining students' learning, the following skills were the most commonly improved: analyze, interpret, explain, evaluate, draw conclusions. Few dispositions were mentioned and improved. A cautious conclusion of this study may be to suggest expanding Abrami and colleagues' recommendations of strategies promoting CT to include an exploratory approach, which emphasizes authenticity, dialogue and mentoring as highlighted by Abrami and colleagues.

Parallel Session - 2.9 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Annelies Pieterman-Bos

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378 How Can the Science Curriculum Be Humanized About Nature of Science?

Sonja M. Mork[1], Berit S. Haug[1], Øystein Sørborg[1], Subashini P. Ruben[1], Sibel Erduran[2]

[1]University of Oslo, Oslo, Norway. [2]University of Oxford, Oxford, United Kingdom

Abstract

In this study, we use the Family Resemblance Approach (FRA) to the nature of science (NOS) as theoretical and analytical framework to investigate the science curriculum from Norway where there is history of emphasizing values like identity, cultural diversity, respect for nature and environmental awareness. The findings show that the dominating aspects of NOS in the science curriculum are scientific practices and social values. The prominence of social values of science is in sharp contrast to comparable analyses, suggesting a particular orientation to NOS that considers the human element in the Norwegian science curriculum.

474 Diversity in Science Education Through a Nature of Science Lens: Incorporating Pluralism into the Curriculum

Genco Guralp, Sarah Hayes

University of Limerick, Limerick, Ireland

Abstract

This paper proposes a pluralistic conception of nature of science (NOS) that would make it applicable to considerations of diversity and inclusion, understood as an issue of social justice in a globalised world. I study pluralistic and perspectival conceptions of science recently developed by historians and philosophers of science, and, on this basis, examine what forms of teaching modules and strategies can be developed that would support the science education needs of contemporary societies composed of diverse and multicultural populations. As many policy documents attest, scientific literacy is a key aspect of "active" citizenship in liberal-democratic societies. We provide a NOS approach to diversity that is situated within these recent discussions of equipping citizens with scientific literacy. The paper rests on two main premises: Firstly, for a proper democratic participation and social inclusion literacy of nature of science is as critical as literacy of scientific content. Secondly, science education research's engagement with matters of diversity and inclusion should be conducted from a socio-political perspective of social justice and social inequality, enabling it to expand its horizons to incorporate traditionally under-represented epistemic dimensions such non-Western (Indigenous) knowledge or community-based citizen science initiatives. In science education, there has been a substantial amount of work done on the question of "nature of science" and how it should be taught. On the other hand, the topic of diversity has recently entered the agenda of the science education practitioners. However, the connection between these two has not been sufficiently addressed in the literature. This paper aims to fill this important gap and contribute to a much needed overall account of diversity based on considerations of nature of science.

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621 Revisiting the Learning Progression of Scientific Modelling

Yi-xuan Liu[1], Xin-hao Song[1], Yuan-yuan Fang[2], Jian-xin Yao[1]

[1]Beijing Normal university, Beijing, China. [2]The Second High School Attached to Beijing Normal University, Beijing, China

Abstract

Scientific modelling acts an important role in science education. This study revisited the learning progression of scientific modeling by first developing a hypothetical learning progression framework. This framework synthesizes two dimensions "understanding of the nature of the model" and "modelling practice", which was based on previous studies on learning progressions of scientific modelling, students' modelling competencies, and an international comparison of curriculum standards. Based on the framework, we further delineated students' performance at each level of the learning progression. To testify and revise

our hypothetical learning progression, the Modelling Progression Assessment (MPA) was developed based on previous instruments assessing students' modelling competencies. 1612 students in grade 4-11 participated the assessment. We used results from Rasch analysis and bookmarking method to test and revising the learning progression of scientific modelling.

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905 University Bachelor Students' Views of the Nature of Science as Enacted in Their Research Practice

Annelies Pieterman-Bos[1], Cathelijne Reincke[1], Rens van de Schoot[2], Marc van Mil[1]

[1]UMC Utrecht, Utrecht University, Utrecht, Netherlands. [2]Utrecht University, Utrecht, Netherlands

Abstract

In this study, we characterized university students' enacted views of the nature of science (E-VNOS) through a combination of discourse analysis and reflexive thematic analysis of bachelor theses, interviews, and written reflections. We combined previously studied aspects of scientific arguments regarding their structure, quality, and language use. Then, we continued to interpret these features in terms of what they tell us about the VNOS that students enact in their research practice. With this approach, we shift the focus of nature of science research from the views students express when nature of science is explicitly discussed (professed VNOS) to the views students enact through their language use when they write scientific texts or talk about scientific research (enacted VNOS). Some examples of E-VNOS that we generated from students' discursive practices are "Data, results, or inscriptions speak for themselves," "Researchers actively interpret data and use them to support claims," "Inconclusiveness is part of science," and "Good scientific research should provide definitive evidence for a theory." We also reflect on how students can enact or profess seemingly conflicting VNOS (mixed views). We emphasize the role of context, and how appropriating academic discourse (e.g. learning the conventions of article writing) affects the VNOS are built during university education.

Parallel Session - 2.10 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Cristina Viehmann

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251 Learning Evolution through Problem-Based Argumentation: The Differential Effects of Types of Interaction and Discourse Across Educational Levels

Antonia Larrain[1], Paulina Freire[2], Patricia López[1], Valeska Grau[3]

[1]Universidad Alberto Hurtado, Santiago, Chile. [2]Pontificia Universidad Católica de Chile, Santiago, Chile. [3]Pontifici Universidad Católica de Chile, Santiago, Chile

Abstract

Evolution through natural selection is a key piece of knowledge, but evidence shows that even undergraduates have a poor understanding of it. Problem-based argumentation may be particularly powerful in fostering conceptual understanding. However: Is collaborative argumentation more effective than individual argumentation? Is there any difference in learning through argumentation in problem-solving settings across educational levels? We conducted three experimental studies. In study 1 sixth-grade students (N = 136) from seven public schools in Chile solved weekly problems of organic evolution (six weeks) in a mixed within and between 2x2 factorial design with between-subject factor problem-based orientation (argumentation versus explanation) and interaction (collaborative versus individual). The students had no formal instruction about evolution. Pre- and post-test knowledge was administered. The results showed significant changes in conceptual understanding in all conditions from pre- to post-tests, except for collaborative non-argumentation. Moreover, the group argumentative discourse significantly predicted delayed-post tests. In study 2 tenth-grade students (N = 126) from three public schools participated in a similar design with the same materials and procedures as in study 1. Students had been taught evolution in the previous year. The results showed that students in the collaborative argumentation condition were the only ones to progress between pre- and delayed post-tests. Argumentative discourse did not predict post-tests. In study 3 pre-service teachers (N = 46) from eight universities participated in a similar design with only two conditions: collaborative and individual argumentation. The results showed that students in the collaborative condition were the only group that significantly gained from pre- to post-tests.

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409 Students' Models and Frameworks on Evolution While Simulating Natural Selection

Noa Ageitos[1], Blanca Puig[2], Laura Colucci-Gray[3]

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Abstract

This study addresses the analysis of students' models and frameworks on evolution in an activity that requires simulating and creating a model that explains natural selection in a real life scenario. The research questions are: 1) How do students' models of evolution differ?; 2) What evolution frameworks underpin students' explanations when building and evaluating a model of evolution? And how do these frameworks change? The participants are five small groups of 10th grade students (N=20) and their biology teacher with previous experience in modelling-based instruction. Data collection includes students' written reports and drawings which were analysed both through content and discourse analysis. Findings show that at first, students believed adaptation to feature at will as a behavioural characteristic instigated by a pre-existing design. After modelling the process of natural selection, the explanations appeared to improve (from Lamarckian to Neo-Darwinian views) and most groups showed accurate explanations

about adaptation. This points to the importance of modelling as an epistemic and dynamic practice that may help students to create new knowledge on evolution and apply them.

967 The Pseudoscience and Post-Truth Dyad as a Challenge for Science Education

Isabel Martins, Marcia Garcia, Bruna Karl Rodrigues da Silva

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Abstract

The contemporary demands of Science Education point to the need to include the discussion of socio-scientific themes in environments that go beyond formal teaching. This was reflected in the context of the Covid-19 pandemic in the discussions related to the prevention of the coronavirus and in the ways in which it is possible to avoid the contagion and spread of the virus: use of masks, adequate physical distance, use of alcohol to clean the hands, among others. In this article, we analyze, in the light of critical discourse analysis, aspects that show a possible relationship between post-truths and pseudoscience through the analysis of a video present on the social media Facebook that concerns Quantum Behavior against the virus. The results reinforce that the rise of alternative views to Science is supported by desires, beliefs and personal emotions even at times when there are well-founded scientific arguments circulating in society. These non-discursive aspects influence the absence of reliable content verification, building an environment conducive to the circulation of pseudoscientific discourses, especially if we consider that we are experiencing a post-truth era. This can be reflected in the context of social media, given that these do not have specific guidelines for confronting pseudoscientific practices, on the contrary, social media are environments that allow the coexistence of different discourses. Therefore, it is necessary to consider the importance of Science Education in different education spaces, since public opinion is shaped not only by scientific arguments but also by subjective aspects, which favors the dissemination of pseudoscientific discourses in a post-truth era and elucidates the importance of decision-making bases on subjects of a socio-scientific nature in the social sphere.

10 Lessons Learned from the Implementation of A Socio-Scientific Issues Approach in Five Mexican High Schools

Cristina Viehmann

Tecnológico de Monterrey, Monterrey, Mexico

Abstract

This study examined students' perceptions about the implementation of the socio-scientific approach in their science classes and how these perceptions relate to their attitudes toward science. Survey data was collected from 550 students in five urban private high schools in Northern Mexico. The degree of perceived exposure to the socio-scientific issues (SSI) pedagogical approach was measured using three dimensions proposed by Zeidler and Kahn

(2014): (1) exposure to real problems; (2) the confrontation with moral-ethical problems and (3) the development of thinking, research, debate and collaboration skills. For the measurement of attitudes towards science, three dimensions present in the "Changes in Attitudes about the Relevance of Science" survey, developed by Siegel and Ranney in 2003, were chosen: (1) interest in learning science, (2) the global and local consciousness developed thanks to science and (3) the connection between science and daily life. Results from a correlation and linear regression analysis showed that students' perceptions on their exposure to SSI can significantly influence their attitudes toward science. Data suggests however that, even though SSI is presented as a declared instructional goal in the five high schools analysed, there are impediments to fully applying the approach in teaching. Implications for strengthening the SSI pedagogical approach in secondary school science classrooms were discussed.

Parallel Session - 2.11 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Olivia Levrini

363 Computer-Aided STEM-Oriented Product Development Through Implementers' Feedbacks

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[1]Başkent University, Ankara, Turkey. [2]Aksaray University, Aksaray, Turkey

Abstract

Science-technology-engineering-mathematics (STEM) learning approaches created great interest in recent years. In addition, STEM contributed to the revitalization and popularization of some innovative constructivist issues for science courses such as product development and entrepreneurship. This study focuses on the use of computer-aided design (CAD) in STEM-oriented product development through technological design cycle (TDC). Design cycles are based on three steps: i) developer team preparing prototypes; b) implementer teams' feedbacks; c) developer teams' improvements. Product was chosen to be a model catapult which had to meet with pre-determined starting criteria and also meet with the entrepreneurship principles. The developer team included two faculty members as product designers and implementer team included three teachers as feedback providers. Implementers constructed the prototypes, shared them with their students, and sent their feedbacks to the team leaders. Product development process lasted six cycles. Although the first prototype was considered theoretically successful by the developers, consensus was only reached after the sixth model. Developers' reflections on using CAD and the role of feedback in a STEM-oriented product development through TDC was discussed throughout the paper.

958 Quantum Atelier Project: Results From an Interdisciplinary Experience Between Art and Science

Sara Satanassi, Paola Fantini, Olivia Levrini

Department of Physics and Astronomy, University of Bologna, Bologna, Italy

Abstract

In this contribution, we discuss the results of the Quantum Atelier project carried out by four teachers and six high school students. It was born after an extra-curricular course on the Second Quantum Revolution, held by us, in which we paved the way for a reflection on what role can arts have to interpret and unpack the current technological and scientific revolutions as cultural revolutions. During the project, students and teachers explored how arts provide a new imaginary, new languages, and aesthetics to reconceptualize some ontological and epistemological aspects at the basis of the Quantum Revolutions. In the end, students produced three very personal artworks that were presented to schoolmates and citizens. In attending the exhibition, we had the perception that something happens: the interdisciplinary experience seemed to have triggered a deep process of internalization of the represented aspects. In light of this, we decided to investigate, through a collective interview, how this experience could trigger these personal rielaborations, which disciplinary constraints of arts and physics, and how their intertwining allows students such internalization. From the way in which students presented their artworks and the final discussion, it seemed that students had appropriated the represented concepts. We carried out a qualitative analysis following the appropriation framework elaborated by the authors (2015). The presence of the appropriation's operational markers in students' discourses suggests that the interdisciplinary experience fosters them to transform scientific discourse so as to embody it in their personal stories, respecting inter-disciplinary rules and constraints. Furthermore, the experience allows students to reflect and grasp more deeply the aspects, and to develop awareness about their skills, nurturing their identities and fostering personal growth. We will present also the analysis we are carrying out about the conditions, namely which inter-disciplinary rules and constraints could trigger the appropriation in this experience.

1254 Investigation of The Effect Of Engineering-Based Activities on Entrepreneurship Perceptions of Secondary School Students

Kayahan Ince, Mehmet Ali Kupeli

Adana Provincial Directorate of National Education, Adana, Turkey

Abstract

The aim of this study is to examine the effect of engineering-based activities applied during the 7-week project on students' perception of entrepreneurship. 36 secondary school students participated in this study, which was carried out using a weak experimental design. Throughout the process, students participated in activities involving different fields such as earthquake engineering, civil engineering, and environmental engineering. The data were collected with

the entrepreneurship perception scale and the data collection tool was applied as a pre-test and post-test. SPSS 22.0 program was used to analyze the data. It is seen that there is a statistically significant difference between the beginning and the end of the project in the entrepreneurship perceptions of the participants (p=.000). As a result of the study, it was revealed that engineering-based activities can positively change the entrepreneurship perceptions of secondary school students.

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471 Exploring University Teacher Educators' Perceptions of STEAM Teaching and Learning Approach

Matej Vošnjak, Janez Vogrinc, Iztok Devetak

University of Ljubljana, Faculty of Education, Ljubljana, Slovenia

Abstract

STEAM education is known as one of the promising practices that involve interdisciplinarity, critical thinking, and creative problem solving. STEAM encompasses science, technology, engineering, arts, and mathematics and aims to improve science education by making it more attractive. The purpose of this study is to explore the opinion of teacher educators in the specific field of STEAM about STEAM teaching and learning. To find out how teacher educators in the field of STEAM view the challenges of integrating STEAM into the curricula that guide their teaching practices, and to identify the factors that they believe have contributed significantly to their competence in teaching in the field of STEAM at the university level. Based on a quantitative research approach, 22 university STEAM teacher educators from 10 European and 4 non-European countries participated in this study. A semi-structured interview was used to assess their understanding of the STEAM teaching and learning approach, individual competencies in the field of STEAM, personal experiences and their opinions. The results show that the majority of respondents are familiar with the acronym STEAM and understand the concept for the most part, but they are not sure about the added value of A in STEAM. Respondents do not feel competent enough and lack skills and knowledge that would improve their competence in dealing with STEAM teaching and learning. Therefore, most respondents do not implement the idea of STEAM teaching and learning in their lectures. It can be concluded from the interview analysis that they would like to see more support and organized courses from the university regarding STEAM teaching and learning.

Parallel Session - 2.12 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Jonathan Osborne

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380 Misinformation in Science: The Response of Science Education

Daniel Pimentel, Jonathan Osborne

Stanford University, Stanford, CA, USA

Abstract

Across the globe there is an increasing concern about the ease with which people accept false or misleading information, even when there is good evidence to the contrary. Some have called this a "Post-Truth" era (McIntyre, 2018). Whether it is the idea that the earth is flat, that vaccines cause autism, or that climate change is a hoax, the willingness of individuals to accept beliefs that have no evidence to support them is disturbing. Some of these beliefs – for instance that vaccines are harmful – endanger not only the lives of those who hold them but the whole community who depends on a high level of vaccination to ensure its health. In this paper, we seek to address the question of what contribution science education can and should make to improve young people's capability to sort reliable information from that which is false or misleading – be it intentional or unintentional. We do this by offering a theoretical argument for the needs of those who are outsiders to science – that is those who do not have the requisite scientific knowledge to evaluate the evidence and arguments for themselves asking what knowledge and competencies are required to be a "competent outsider" to science (Feinstein, 2011).

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837 Students' Critical Evaluation of Science-Related Information: Teachable Moments for Nature of Science-in-Society

Mari Sjøberg

University of SouthEastern Norway, Borre, Norway

Abstract

Research shows that young people struggle to critically evaluate science-related information on the internet. In this study, we are investigating challenges and opportunities by focusing on the credibility of the source, relevant expertise, and scientific consensus when students are evaluating information. The study is based on a collaboration between researchers and pre- and in-service science teachers in Norway. The aim is to develop digital reading strategies for different grade levels and a progression in science media literacy from elementary to undergraduate education. Through various classroom interventions designed together with teachers, we explore different reading strategies in the classroom. The gathered data are video data from students' head-mounted cameras, students' text, pre-posttest, and interviews. Our initial findings suggest that focusing on credibility, expertise, and consensus when evaluating science-related information provides teachable moments for nature of science and nature of science-in-society. However, it also shows that this reading strategy requires knowledge about the social-institutional aspects of nature of science which is an area that has not received much attention in curriculums all over the world.

1148 Science Education in the Misinformation Era: The "COVID Kit" in Brazil

Marcos Ferreira, Cibelle Silva

University of São Paulo (USP), São Carlos, São Paulo, Brazil

Abstract

To mitigate problems associated with fake news and misinformation regarding scientific issues, science education must prepare students to deal with current media challenges, such as filter bubbles and echo chambers. In this presentation, we analyse a course for pre-service science teachers about the recent episode of "COVID kit", consisting of chloroquine, hydroxychloroquine, and ivermectin. Even though a scientific consensus was quickly established, denying the prophylactic claims for such substances, the Brazilian government of the period distributed millions of kits for the population in public and private health systems with the support of several medical doctors. What is at stake is not to expect that students or the non-specialist public will be able to read the scientists' articles and judge for themselves since epistemic dependence is a reality in a society with so much expertise. There is a need to trust experts. So the big question is how to choose the right experts or whom to trust. In this presentation, we discuss how a better understanding of the nature of science can foster science media literacy, avoid problems related to the belief and use of the "COVID kit", and how to prepare teachers to deal with misinformation in science classes.

1284 Understanding the Importance of Scientific Literacy with Examples From the COVID-19 Pandemic

Hülya Güngör, Emine Uğur, Emine Kaçmazoğlu, İbrahim Ünal

İnönü Üniversitesi, Malatya, Turkey

Abstract

Natural disasters such as pandemics, floods, forest fires, and earthquakes we have experienced in the last 3 years have shown us that accessing reliable, fact-based information is essential for making life-saving decisions and participating in all areas of society. In such extraordinary times, we frequently encounter scientific concepts and scientific information, especially non-scientific fake news, false and misleading information on the internet, social media, visual and written media. It is very easy for today's individuals to access and share these fake, false and misleading information through digital tools. However, in order for them to be successful individuals of tomorrow, they must be critically thinking, questioning, researching, problem-solving skills, in short, they must be scientific literate individuals. In this study, the importance of scientific literacy will be discussed through examples of non-scientific discourses, fake news and conspiracy theories that we frequently encounter during the pandemic process. The research was carried out by analysing documents from qualitative research methods. The obtained data were evaluated by comparing them in terms of scientific literacy aspects. We can classify the most frequently encountered information during the COVID 19 pandemic process as follows: Various scientific concepts; Information on the origin of the virus; Vaccine hesitancy, vaccine

refusal and anti-vaccine; Conspiracy theories; Statistical information about the disease; The spread of the disease; Preventive measures; Complementary medicine applications. In today's world, we can emphasize that scientific literacy is an important skill and competence in recognizing manipulative practices in the media, avoiding misinformation, making right decisions, and solving problems in the light of scientific principles, both for the individual and the society.

Parallel Session - 2.13 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Sakari Tolppanen

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680 Climate Change Awareness Profiles of Japanese Primary School Children: A Pilot Study

Khalifatulloh Fiel'ardh, Hiroki Fujii

Okayama University, Okayama, Okayama, Japan

Abstract

The present pilot study aimed to achieve two primary objectives: (1) to develop and validate a Japanese version of the Climate Change Awareness Scale, and (2) to classify primary school children from Hiroshima prefecture, Japan into groups based on their climate change awareness profiles using the scale. The sample of this study consisted of 181 primary school children from three schools. Results from the pilot testing revealed that the Japanese Climate Change Awareness Scale exhibited a high level of reliability and validity, and was composed of two factors: perception and action. A two-step clustering analysis was conducted to identify trends in the children's climate change awareness. The clustering analysis identified four distinct groups of children: active-reflective, active-impulsive, passive-apathetic, and passive-contemplative. These findings may inform future studies on the effective integration of climate change education into the primary school science curriculum, by developing lesson plans tailored to the specific needs of each group.

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808 Examining How Climate Change Competencies Develop During Three Years of Finnish High-School

Sakari Tolppanen[1], Jingoo Kang[2]

[1]University of Eastern Finland, Joensuu, Finland. [2]University of Eastern Finland, Jonsuu, Finland

Abstract

This study explores Finnish high-school students (N=1916) climate change competencies, namely their climate change related knowledge, attitudes, emotions and values. Students (grade 10-12, aged 15-18) filled out a questionnaire with 89 items, on 9 different dimensions. The findings show that students have moderate levels of knowledge on the science of climate change, but lack knowledge on mitigative actions. Furthermore, though students are worried about climate change, they show a lack of willingness to take mitigative actions in their personal lives, but especially as members of society and through career choices. In other words, students show a lack in climate competence. Students also show proximity bias, in that they think that those in their close proximity (family, classmates etc.) live more sustainable lives than others. Finally, the findings show that climate competencies remained unchanged when comparing grade 10 to grade 12 students, indicating that a school reform is needed in order to help students become sustainable citizens, as is the aim set by the UN and the EU.

946 Creating a Model of Climate Change Literacy Based the Systematic Literature Review

Helin Semilarski, Helen Semilarski

University of Tartu, Tartu, Estonia

Abstract

A large number of articles in the field of science education reflect on scientific literacy as the main goal of science education. A major part of scientific literacy is climate change literacy. The main aim of this theoretical article is to come on consensus and to conceptualise the term climate change literacy (CCL) more clearly and to present a theoretical model of CLL, composed on the basis of systematically analysed articles. This theoretical concept includes 5 dimensions of CLL: (1) cognitive dimension; (2) affective dimension; (3) interdisciplinarity and transdisciplinary dimension; (4) dimension of climate change related career awareness; (5) dimension of action-based citizenship.

795 An Exploration of Irish Children's Science Capital

Shannon Stubbs[1], Sarah Carroll[1], Jennifer DeWitt[2], Muriel Grenon[1]

[1]University of Galway, Galway, Ireland. [2]UCL, London, United Kingdom

Abstract

There is a need to understand and support the development of young people's science capital and science identities. Though children generally have positive views of science many, especially those from underrepresented backgrounds, do not envision themselves becoming scientists or feel science is 'for me'. This research aims to explore the application of the concept of science capital in the Irish context. The research will focus on investigating the science capital levels of children between the ages of 10 to 13 years old in 5th and 6th class primary schools

on the west coast of Ireland. Children's levels of science capital will be explored through a questionnaire, and, for a subsample of participants, through a semi-structured interview. Preliminary findings from a small-scale pilot of the questionnaire suggest that the concept of science capital is a suitable lens through which to examine Irish children's science engagement and identity. However, deeper exploration is needed and the findings of the main study will be presented at this conference.

Parallel Session - 2.14 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Sevde Nur Yerişenoğlu

640 The Unintelligibility of Slow Violence in Science Education

Ajay Sharma[1], Ramnarayan Kalyanaraman[2]

[1]University of Georgia, Athens, GA, USA. [2]Grassroots Institute, Montreal, QC, Canada

Abstract

Episodes of quick violence, such as hurricane and rapid floods are expected to proliferate in the Anthropocene, and often catch our attention. This chapter, however, focuses on another kind of violence that may also come to define the Anthropocene. This is the slow violence induced by the global hyper-capitalism fueled unrelenting degradation of local socioecological regimes. Dispersed across space and time, slow violence has now become endemic to most resource-dependent communities living in fragile, disturbed socioecological regimes. Lacking sensational shock value of quick violence and difficult to recognize and act against because of its gradual, dispersed, and accretive nature, slow violence has proved to be just as lethal for marginalized communities around the world. We make the case that slow violence has been rendered unintelligible for students by the dominant curricular and environmental discourses that shape science education's representation of and our relationship with the world.

743 An Operational Action Competency Approach to Transforming Education for Sustainable Development by Action Based In-Situ Interventions

Mette Hesselholt Henne Hansen[1], Karen Seierøe Barfod[2], Michael Jes Vogt[3], Nanna Villumsen[3], Søren Witzel Clausen[3]

[1]VIA University College, Silkeborg, Denmark. [2]VIA University College, Nr Nissum, Denmark. [3]VIA University College, Aarhus, Denmark

Abstract

Education for Sustainable Development, ESD, is among the most intensely debated topics in the field of educational research. However, to teachers in primary and secondary school, the

concepts underlying ESD are often perceived as abstract and complex, and there is growing concern that ESD may cause anxiety and distress. This presentation discusses outcomes of an intervention study, where science teachers from 50 Danish schools develop lesson plans in a design-based research framework through three iterations. Our approach targets three main challenges to teaching ESD in primary and secondary school: (i) The role of science in ESD: Sustainable development is rightfully perceived as a topic transgressing traditional subjects and classes. However, science plays a key role to understanding the relationships underlying sustainability problems. We use the Stockholm Resilience Centre "wedding cake model" of the UN sustainable development goals to enable discussions of the relationships between the ecological, social and economic sustainability domains, and how these can be used to identify overlaps and conflicts of interests between individual goals. The ecological domain is directly defined by science concepts, while the other domains can be used to introduce SocioScientific Issues related to the goals. (ii) The complexity of ESD: The scale of complexity inherent to sustainability issues can be daunting. In the form of a physical artifact, we introduce UNESCOs eight key competencies for sustainability as a didactic design tool and to guide student discussions. Rather than downplaying or misrepresenting the inherent complexity, this approach can help teachers prioritize their didactic designs. (iii) Engagement and empowerment: All design objects in our project involve outdoor learning environments and local stakeholders, with students engaging actively in local sustainability actions. We present results from our first two iterations with examples from four cases studies, teacher and student interviews and pre- and post-survey data from participating schools.

1246 Analyzing Pre-Service Science Teachers' Futures Thinking

İlknur Güven[1], Sevde Nur Yerişenoğlu[2], Yağmur Aykul[1], Merve Günsal[1]

[1]Marmara University, Istanbul, Turkey. [2]Boğaziçi University, Istanbul, Turkey

Abstract

Research on the future studies of teachers and prospective teachers is often limited to short-term trajectories. In this study, a future studies perspective was used to draw attention to the long-term visions of pre-service science teachers regarding their jobs. An exploratory study was planned on pre-service teachers' images of a future work day. For this, the method of future narratives, which is well established in the field of future studies, was used. 50 pre-service science teachers participated in the study. At the end of the 2022-2023 fall semester, 4th grade pre-service science teachers studying at a state university in Istanbul were asked to write an article titled "my first day of work in 2040" by asking an open-ended question. The obtained data were analyzed by content analysis. It has been observed that they mostly wrote about the educational environments, the physical conditions of the school and the materials they will use in the lesson. It can be said that adapting such methods in teacher education can enable pre-service teachers to form more creative thoughts about the future and create new types of projections.

Parallel Session - 2.15 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Tuba Gokpinar

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279 The Voice of Policymakers, Professional Development Leaders, and Teachers who engage in Climate Change Education: A Cross-Country Comparison

Orit Ben Zvi Assaraf[1], Vaille Dawson[2], Efrat Eilam[3], Tuba Gokpinar[4], Daphne Goldman[5], Nofar Naugauker[1], Gusti Agung Paramitha Eka Putri[6], Agung Wijaya Subiantoro[7], Sakari Tolppanen[8], Helen Widdop Quinton[3], Peta White[9]

[1]School of Education, Ben-Gurion University of the Negev, Beer-Sheva, Israel. [2]Graduate School of Education, The University of Western Australia, Perth, Australia. [3]The College of Arts and Education, Victoria University, Melbourne, Australia. [4]Institute of Education, University College London, United Kingdom. [5]Beit Berl College, Tel Aviv University, Tel Aviv, Israel. [6]Nossal Institute for Global Health, University of Melbourne, Melbourne, Australia. [7]Department of Biology Education, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia. [8]Department of Chemistry, University of Eastern Finland, Joensuu, Finland. [9]Faculty of Arts and Education, Deakin University, Burwood, Melbourne, Australia

Abstract

Climate Change (CC) is currently the most pressing existential threat confronting global societies, natural ecosystems, and the fabric of life on Earth as we know it. Yet, research addressing the perspectives of the key players involved in developing and implementing secondary school-based climate change curricula at a cross-country national level is scarce. This study asked: How do educational practitioners conceptualize climate change education in relation to: a) its primary learning goals; b) appropriate approaches for implementation and c) the enablers and inhibitors associated with implementing climate change curricula. In order to answer these questions, we explored the voices of the key players in climate change education (CCE) from five countries (Australia, England, Finland, Indonesia, and Israel). We asked policy makers, professional development (PD) leaders and science teachers—all of whom are actively engaged in CCE—about their perceptions regarding the implementation of CCE in their countries, and about their vision for how this should be done. Ultimately, we aimed to map out the various ways of applying CCE, and offer a repertoire of approaches for countries to draw upon. The findings indicate consensus regarding the importance of CC, combined with a lack of agreement regarding the epistemological nature of CC and, thus, its position in the curriculum.

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293 A Model on 'Learning to Action' towards Transformative Climate Change Education

Lilia Halim, Mea Yeang Chan

UKM, Bangi, Selangor, Malaysia

Abstract

Climate change issues such as global warming must be addressed by changing society's behavior and establishing policies that are more cultural based. Education is seen as one of the most effective platforms to change people's behavior. However, addressing climate change challenges that are complex, and would require a different type of education. It has been argued that transformative education is deemed necessary – to equip society with new knowledge and skills – and also to inculcate attitudes and values that encourage society to act on for national and global good. Thus, the research objective is to propose and validate a hypothetical model to explain school students pro environmental behavior regarding energy conservation. In particular, how the model varies based on values that are held by Malaysians. This research employs a mixed method sequential research design- 1) To explore and determine the factors influencing the students' behavior regarding energy conservation and 2) To evaluate the hypothesized model. 25 experts were involved to determine and validate the factors in the hypothesized model. Total number of students involved (Form 2 aged 14 years old) in the research is n=821, sampled through stratified technique (school location, ethnicity). Data will be analysed using the Fuzzy Delphi technique and the structural equation modelling (SEM-AMOS). The novelty of this research is twofold: a) An extended model of Theory Planned Behavior is used to predict and explain energy conservation behavior of secondary school students and b) Students' culture as a moderating factor – that addresses the practical research gap towards an effective and realistic climate change policies, awareness and training programs relevant for a diverse society like Malaysia.

1142 Development of Middle School Students' Attitudes Toward Nature, Interest in Nature, and Connectedness With Nature During a Three-Year Environmental Education Programme With Direct Nature Experiences

Petra Bezeljak, Andrea Möller

University of Vienna, Vienna, Austria

Abstract

One of the main goals of environmental education is to raise people's awareness of nature conservation. To promote ecological behaviour, environmental education focusses on several environmental competences, e.g. cultural beliefs, environmental perception, specific ecological behaviour etc. (Roczen et. al. 2014; Bogner, 2004). Direct and indirect experience of nature plays a key role in human physical, emotional, intellectual, and even moral development (Kahn and Kellert, 2002; Gebhard 2009). Previous studies have demonstrated that students with direct experiences of nature become more motivated to care and act for environment (Schultz,

2002). However, to our knowledge, most studies conducted in the school context so far only describe the effects of short term interventions. In this research project we investigate the possible impact of a 3-year teaching intervention with direct nature experience on middle school students' connectedness with nature, interest in nature, nature-protective behaviour, responsibility for nature conservation, and environmental values. The main research questions are: 1.) How do attitudes develop, and how does environmental knowledge progress over a duration of a two years with or without an intervention with direct nature experience? 2.) Is there any correlation between knowledge, attitudes and interest; if yes, how do they influence each other? 3.) Does time spent in nature impact the development of environmental attitudes, interested in nature and/or progress of knowledge? The three -year intervention study with 5 data collection points (T0-T4) is conducted with 370 students starting grade 6. Questionnaire includes items from known scales, i. e. the 2-MEV (Bogner et. al, 2015), Inclusion of Nature in One Self (Schultz, 2002), Children's Environmental Attitudes Knowledge Scale (Leeming et al., 1995). Results of the pre-test (T0) show positive attitudes toward nature but lack of general environmental knowledge. Results of the Post-Tests (T1 – T4) will be presented in ESERA Conference 2023.

1224 In-Person vs Online Delivery: The Case of STEM Teachers' Continuing Professional Development (CPD) Programme in the UK

Tuba Gokpinar[1,2], Clare Gartland[1]

[1]University of Suffolk, Ipswich, United Kingdom. [2]UCL Institute of Education, London, United Kingdom

Abstract

This study evaluates the shift from in-person to online delivery of the UK-based national science, technology, engineering and mathematics (STEM) teacher professional development program, ABC. The aim of the program is to provide support and resources to teachers in the science, technology, engineering, mathematics, and computing fields through training and networking activities. The program is known for its focus on hands-on and physical learning experiences, which were impacted by the COVID-19 pandemic, leading to switch to online meetings. The study uses data from semi structured interviews with regional network leads (n=13) and teachers (n=24) from different geographical areas in the UK, observations of network meetings (online n=4 and face-to-face n=2) and observations of training days (online n=4, face-to-face n=2). Interviews explored the views and experiences of regional leads to better understand the operation of the ABC network with an aim to identify effective ways of working and issues and challenges they have faced. Interviews were transcribed and an initial thematic analysis was undertaken. Themes were initially generated inductively and then developed and refined drawing on literature relating to professional development, networks and communities of practice, self-efficacy, STEM pedagogies and inclusivity. The data collected from these methods was analyzed to identify the challenges and opportunities associated with the transition to online delivery and how the program could be improved. The study revealed several difficulties in moving the program online, including limited social interaction, difficulties

in conducting hands-on training, and technical issues. Regional leads attempted to address these issues by using various strategies such as the use of online tools, resources, and mail-in materials. A hybrid model of online and in-person delivery is being considered as a post-pandemic approach as it is seen to provide greater accessibility while preserving the benefits of in-person interaction.

Parallel Session - 2.16 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Debora Marchak

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340 What Has Been Discussed About Chemistry on Instagram? Examining Comments Posted in Brazilian Publications

Wilmo Ernesto Francisco Junior, Miyuki Yamashita, Marlos Machado

Federal University of Alagoas, Arapiraca, Alagoas, Brazil

Abstract

Social media have provided new forms for scientific discourse, and an understanding of science communication on such platforms may contribute to enhance this process. This work therefore focused on analysing comments from Instagram posts pertaining to Chemistry. The survey employed ethnography as a research method and resulted in a total of 371 comments. An analysis of these comments indicated they were favourable to science, although most of them (329) discussed chemistry only superficially, revealing generic reactions to express cheeriness. Based on 42 comments concerning scientific issues, conceptual knowledge was found to be the main category to promote knowledge circulation. In addition, questions posted by users demonstrated a potential to improve science public communication through participatory digital cultures.

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420 Leaning Outcomes of STEM-Workers Visiting School Classes

Anders Vestergaard Thomsen

University Collage Absalon, Roskilde, Denmark

Abstract

´The Danish Society of Engineers´ has made a program for STEM-employees where they visit school classes. The program is called ´Book an expert´. The experts are joining the program as volunteers and visit in a school class for 1-2 hours. The program offers the STEM-workers a short didactical course (2x4 hours) where they learn about science concepts in school curriculum, how to meet the students level of knowledge, ask open questions, how to start scientific

debates in class, and learn how to make small scale scientific experiments with the students. In short, experts learn how to motivate students and how they can become role models for students to learn science and work in STEM fields. In this study, we investigate which elements the STEM workers use from the course and which learning outcomes the students get from the visit. The theoretical framework used in this study is part of the learning in a context of Socioscientific Issues (SSI) (Zeidler & Nichols, 2009) mixed with learning outputs from ´out-of-school´ settings (Braund & Reiss, 2006). The evaluation consists of a qualitative and quantitative evaluation. The qualitative evaluation is based on classroom observations of 13 visits to 13 schools, 18 focus group interviews with a total of 67 students as well as individual interviews with 11 teachers and 13 experts. The quantitative part consists of answers to questionnaires from 271 students divided into 4th - 10th grade and answers from 19 teachers and 8 experts. On the basis of the study, it can be concluded that the 'Book an expert' visit classes in lower primary and secondary school works extremely well and is experienced as interesting and rewarding by pupils, experts and teachers alike. Furthermore, it is assessed that the scheme fulfills many of the development project's short-term and long-term goals - which will be oral presented.

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431 Exploring Middle School Students' Perceived Value of Science Communication Meetings

Ipek Paksoy, Melike Hanedar, Gaye Ceyhan

Bogazici University, Istanbul, Turkey

Abstract

The dissemination and acceptance of misinformation/disinformation and the denial of scientific claims and facts have become increasingly common practices in the post-truth era in which we live. The recent global pandemic has reaffirmed the importance of science communication (SC) in a dialogical model that supports public engagement with science. SC promotes scientific literacy by sharing knowledge and attitudes about science. For successful SC, it is crucial to consider and address students' expectations and values towards SC activities in their planning and implementation. To promote this, this study organized SC sessions with 7th-grade students (N= 84) that brought students together with scientists about the three units in the science curriculum. This study investigated how valuable middle school students found the SC experience in the context of expectancy-value theory. Results indicated that the utility, achievement, and intrinsic value students attached to the SC sessions increased after each session. The results also showed that the frequency of students' value-related comments about the best part of the meetings had increased for intrinsic and attainment value. For the first two meetings, the most frequently mentioned category was the meeting structure category, which includes comments about the question-answer nature of the meeting. This study contributes valuable information to the existing literature on SC as a powerful context for expectancy-value theory and guides teachers and educational researchers in organizing effective SC meetings.

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339 Facilitating the Development of Interest through Personalized Chemistry Learning in a Competition Setting: A Retrospective Study

Debora Marchak, Miri Kesner, Ron Blonder

Weizmann Institute of Science, Rehovot, Israel

Abstract

Aiming at increasing high-school students' motivation to study chemistry, a National Projects Competition was developed and launched in 2008. In a previous evaluation, it was found that participation in the competition increased the students' motivation to learn chemistry, and that it significantly contributed to its participants in terms of interest, enjoyment, and importance. In this study, we aimed at elucidating the nature of the motivational processes supported by the competition's format, and at pinpointing the possible underlying mechanisms by which participation positively affected students' motivation. Thus, we examined the possible relationships between the competition format and interest development in relation to motivation. Forty-three competition ex-participants were asked to complete a questionnaire that included both Likert-like and open-ended questions. The resulting quantitative and qualitative data were analyzed by a mixed-methods approach. The findings suggest that the unique competition format facilitates personalized learning and the further development of a personal interest in chemistry that the participants seem to inherently possess. The combination of personalized learning and the contextualization of content seems to give rise to a non-conventional, self-directed learning process that targets interest, leads to the nourishment of intellectual and emotional needs, and is connected to the motivation to learn. We propose that this non-formal educational format be implemented as a means of complementing the learning of science in traditional school settings, to increase adolescents' motivation to study science.

Parallel Session - 2.17 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Pınar Fettahlıoğlu

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260 *Who is represented in science courses?* The Impact of Highlighting Counterstereotypical Scientists through Student-Authored Reflective Assignments

Dax Ovid[1], Maurina Aranda[2], Jeff Schinske[3], Kimberly Tanner[4]

[1]University of Georgia, Athens, Athens, GA, USA. [2]Southern Illinois University Edwardsville, Edwardsville, IL, USA. [3]Foothill College, Los Altos Hills, CA, USA. [4]San Francisco State University, San Francisco, CA, USA

Abstract

The history of science, as depicted in science curriculum, tends to feature scientists who are predominantly white, elite, non-disabled, heterosexual, Western European cis-gender men. This narrow range of personal characteristics does not reflect the diversity of students we aim to support in shaping the future of scientific discourse. Why might representation of scientists in our curriculum matter? Grounded in the theoretical framework of possible selves and the conceptual rationales of scientist stereotypes and science identity, an initial study conducted in the context of a two-year community college in the United States showed that students who could relate to scientists, and described scientists beyond stereotypes, scored higher on exams than students who did not relate to scientists. Subsequently, an intervention was designed to foster students' relatability to and nonstereotypical descriptions about the types of people that do science: Scientist Spotlight assignments. These assignments teach content through stories of counterstereotypical scientists – such as Black scientists, LGBTQIA+ scientists, disabled scientists, working class, first-generation college-going scientists, and intersections thereof. By synthesizing research and biographies of counterstereotypical scientists, these assignments engage students in written reflections on concepts they learned about, questions they have, and metacognitive reflections about the types of people that do science. Here we will report on two studies with significant outcomes implementing Scientist Spotlights. Study 1, with undergraduate students who authored Scientist Spotlights, showed significant shifts in relatability to scientists for the student-authors and also for students across demographic groups in a range of college-level biology courses. Study 2, conducted in collaboration with 18 secondary school teachers, showed modest but significant shifts in science students' relatability to scientists following the intervention. These findings urge us to consider a fundamental shift in science curriculum, not only to promote equitable student success in diverse classrooms but also an equity-minded scientific workforce.

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141 Fixated on Exactness - Identity Narratives of Young Women in Post-Compulsory Physics

Emilie Gertz

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Abstract

This study explores how 33 young women construct their identities and make meaning of their experiences in the meeting with post-compulsory upper secondary school physics. Through an identity framework the interplay between the young women and the disciplinary educational context is explored. The study draws on survey-data and semi-structured individual interviews with the young women. Using a thematic analysis, the findings show a celebration of exactness combined with a hierarchal learning process building on top of prior knowledge. Exactness was especially expressed as a similarity to mathematics but also in being able to follow a manual and fitting experiments into theory. The hierarchal learning made lower secondary school physics essential for following the lessons. Consequently, upper secondary school physics

offered limited possibilities to form a sense of identity, especially when not being able to transfer competences from lower secondary school or when being unsure about performing the exactness.

1191 Validity, Acceptability, and Procedural Issues of Selection Methods for Graduate Study Admissions in the Field of Sciences, Technology, Engineering, and Mathematics (STEM): A Mapping Review

Anastasia Kurysheva, Harold van Rijen, Cecily Stolte, Gönül Dilaver

UMC Utrecht, Utrecht, Netherlands

Abstract

This review presents the first comprehensive synthesis of available research on both cognitive and noncognitive selection methods for graduate education admissions. It focuses on STEM disciplines and covers the period between 2005 and 2020. This is the first review on both cognitive and noncognitive selection methods in graduate education. A systematic search of literature delivered ten categories of graduate selection methods: 1) prior grades, (2) standardized testing of academic abilities, (3) letters of recommendation, (4) interviews, (5) personal statements (i.e., motivation letters), (6) personality assessments, (7) intelligence assessments, (8) language proficiency, (9) prior research experience, and (10) various, rarely researched selection methods that do not fall under more common methods above (such as resumes, selectivity of prior higher education institution (HEI), former (type of) HEI, amount and quality of research experience, or composite scores). Each category was critically appraised against the following evaluative quality principles: predictive validity and reliability, acceptability, procedural issues, and cost-effectiveness. Gaps and further directions in research literature were identified. Theoretical, practical, and social implications of using (non-)evidence-based selection methods are discussed. Overall, this synthesis of the latest findings in the field of graduate selective admissions allows admissions committees to choose which selection methods to use and which essential aspects of their implementation to account for. The results of this review are relevant for a wide range of specialists: researchers in STEM higher education, admissions committees, administration of universities and STEM faculties/graduate schools, university policy makers, as well as student associations/representatives.

977 The Effect of Argumentation Supported STEM Education Activities on Scientific Reasoning Skills of Teacher Candidates

Pınar Fettahlıoğlu

Çukurova University Educational Faculty Science Education Department, Adana, Turkey

Abstract

Science education aims to educate individuals as science literate. Individuals who are science literate; He basically uses the science subject-concepts he has learned to solve the problem he encounters in daily life by using scientific process and life skills together, aims to work in

cooperation with other people in life, and explains his views consistently by using scientific reasoning skills. One of the approaches that will contribute to the development of scientific reasoning skills is STEM education and argumentation-based learning approach. Among the reasons for the widespread use of these two models is the fact that students use their scientific reasoning skills actively, while defending their claims, by putting forward justifications and strengthening their arguments with expressions that will support their justifications. From this point of view, it is aimed to investigate the effects of Argumentation-Based Learning approaches applied in the science laboratory course on the scientific reasoning skills of teacher candidates. For this purpose, a quasi-experimental experimental design with unequal pretest-posttest control group from the quantitative research method was used. In the study, 1 experimental and 1 control group were formed. The Scientific Reasoning test developed by Yüksel and Ateş (2019) was used to collect data in the study. The research was carried out with 3rd grade science teacher candidates studying at a state university in the fall semester of 2021-2022. Descriptive statistics, dependent and independent group t-test were used in the analysis of the data. In the experimental group, argumentation-supported STEM education activities were applied, and in the control group, they were taught in accordance with the curriculum. According to the results obtained, it was seen that the argumentation supported STEM education activities contributed positively to the scientific reasoning skills of the students.

Parallel Session - 2.18 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Majd Zouda

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523 Investigation of Science Teachers' Scientific Worldviews in the Context of Multicultural Theories

Funda Özsoy, Mustafa B. Aktan

Hacettepe University, Ankara, Turkey

Abstract

Multicultural education is not just the education given in a region where different nationalities coexist. All people with different customs, origins and beliefs in a society can contribute to the formation of a multicultural environment. For reasons such as war, education, and migration, people may have to live outside the country they were born in. This leads to the emergence of cosmopolitan societies, where different cultures coexist. Today, multicultural education can create important but different effects in all areas of education. Studies have been conducted on the effects of multicultural science education on students' scientific worldviews. However, the views of science teachers on multicultural science education are not clear enough. For this reason, the aim of the study is to examine the scientific worldviews of science teachers within the framework of multicultural science theories. The sample for the study consisted of science

teachers working in Turkey. The research is done by following qualitative research methods and the data was collected through a survey, a demographic information form, and semi-structured interviews. The data obtained from the teachers who voluntarily participated in the research was first checked and analysed by the descriptive analysis method. In the next stage, the data collected was transcribed, coded, and analysed with qualitative research methods. The findings were interpreted as thematic codes, and a research report was written. The ideas of science teachers within the framework of multicultural and universal science theories, and their effects on the teachers' scientific worldviews were revealed by examining the results.

535 Why Science Education and for Whom? the Contributions of Science Capital and Science Bildung

Lars Ulriksen, Henriette Tolstrup Holmegaard, Line Skøtt Nicolaisen

University of Copenhagen, Copenhagen, Denmark

Abstract

This conceptual paper discusses the contributions of the two concepts, science capital and science Bildung, and how they complement each other. Science capital offers a way of discussing inclusion and exclusion in science education, while science Bildung focus on the role of science education in educating autonomous, knowledgeable democratic citizens. Further, the paper discusses an aspect of Bildung where science education could play a role and at the same time present a different kind of relevance in the process of finding out who one is.

576 Ten Years After – Trajectories of Science High School Students

Eva Lykkegaard[1], Lars Ulriksen[2]

[1]University of Southern Denmark, Odense, Denmark. [2]University of Copenhagen, Copenhagen, Denmark

Abstract

This paper follows up on a previous longitudinal study of the educational choices and trajectories of STEM capable and interested high school students. Based on qualitative interviews with the students ten years after their high-school graduation, it explores the trajectories of the students in the period since high school. We find that the students' educational trajectories after some changes within the first couple of years are fairly stable. The students' narratives show that the social relations appear very important for their completion. We also find that the students are still engaged in reflections concerning their career paths that to some extent includes changing from the disciplinary path they chose. Concerns related to having a family appear particularly importance, but experiences related to work also spark thoughts about where to go.

587 Embracing The 'SEM' in STEM: Views on Technology in An Elite School

Majd Zouda

University of Toronto, Ontario, Canada

Abstract

Despite the plethora of research about STEM education, a still underexplored area of such research is elite schools. Elite schools are well-known for their significant roles in socializing their students into elite groups and preparing them to assume leadership roles, contributing as such to social stratification. When acknowledging that STEM fields tend to have and produce their own status hierarchy, and that a main goal of dominant forms of STEM education is to 'improve skilled STEM workforce', examining how STEM education is conceptualized and practiced in elite schools, and for what purposes, can then provide better understanding of, and new insights on, privilege making and social inequity. Using Critical Discourse Analysis, this research examines meanings of excellence and distinction in STEM (education) in an elite, independent co-educational high school in Canada. It particularly reports on available views on technology and how these conceptualizations might contribute to elite identification. Findings revealed an overarching discourse of *leadership* that largely shaped valued STEM learning experiences. Findings also revealed selective embracement of the 'SEM' in STEM, with adopted meanings of technology prioritizing understanding concepts, ways of thinking, and academic ties. Significance of these findings are discussed.

Parallel Session - 2.19 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Eilish McLoughlin

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941 A Model for Developing Science Teacher's Adaptive Expertise

Ron Blonder

Weizmann Institute of Science, Rehovot, Israel

Abstract

Scientific knowledge has advanced at an extremely rapid pace in the last decades, whereas the science curriculum has generally lagged behind. In most countries the contents of the science curriculum have not dramatically changed over the years; however, the gap between contemporary research and the school curriculum has expanded every year. Consequently, science teachers are not required to adapt their expertise according to new scientific knowledge in order to keep abreast of rapid advances in the field. However, many chemistry teachers tend to continuously learn about cutting-edge chemistry research and some even incorporate this new knowledge into their teaching. This gap between the demands of the

existing curricula that focus on the final exams, and the contemporary knowledge of chemistry may lead to the development of an adaptive expertise disposition. In this theoretical paper, I will describe a model for developing teaching adaptive expertise, and I will discuss the possible contribution of two novel stages to teachers' professional development: 1) identifying the insertion points of the contemporary contents with the school science curriculum and 2) planning a lesson for integrating contemporary science within the existing curriculum. I suggest that this model can be adopted by science educators who conduct PD programs about contemporary science for science teachers for developing teacher's adaptive expertise. I will utilize the theoretical framework of teachers' adaptive expertise and discuss both its contributions and limitations when analyzing the development of teachers' knowledge and practice.

845 Novice Physics Teachers' Experiences of Transition into the Workplace

Deirdre O'Neill, Eilish McLoughlin

Dublin City University, Dublin, Ireland

Abstract

One of the most challenging periods in a teacher's career is their transition from pre-service education to the workplace, i.e., working in school as a newly qualified teacher. Schlossberg (1981) highlights that in order to examine an individual as they experience a transition, the transition must not be assumed. Transitions can be anticipated, unanticipated, an event or non-event but it must be characterised by the individual to be considered a transition. This study's method and findings were cognisant of this underlying principle and provided an evidence-based approach to identify teacher transitions through the teacher voice. The study of six novice physics teachers highlights the novel way that trends in themes, generated from teacher data, can inform the transition that teachers are undergoing at a specific moment in time. Here, the teacher's journey as a novice has been documented and the teacher voice is at the center of the findings. The findings presented in this study highlights trends in teachers' experiences and identified multiple transitions that overlap and span the entirety of their final year in university and first year of teaching.

1121 Scaffolding Gender Conscious Pedagogies in Preservice Science Teacher Education

Tekla Canger, Ea Maj Dobel, Maria Rejkjær Holmen, Bjørn Friis Johannsen

University College Copenhagen, Copenhagen, Denmark

Abstract

This study reports from a collaboration between researchers, educators, and preservice science teachers on developing gender conscious approaches to science education in preservice science teacher education. The methodology used is a participatory experimental and

formative setup, in which iterative educational development work is used to realise the intention. The result presented here, is an emerging model for developing gender conscious education, which centrally makes use of partial perspectives. For the educator to see and address their gendered practices, they need to look to their students' actions and experiences. For the students to tie their gendered practices to science, they need to look to their pupils' practices; and vice versa. By engaging with students about their gendered experience, educators qualify their practice. Consequently, it appears productive to think of gender consciousness as a performative aspect of pedagogy.

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552 Scandinavian Approaches to Continuing Science Teacher Education: What Can We Learn from an International Literature Review?

Christina Dahl Madsen[1], Stine Mariegaard[2], Chunfang Zhou[3], Steffen Elmose[4], Henrik Levinsen[5], Jørgen Haagen[6]

[1]VIA University College, Aarhus, Denmark. [2]University College Lillebælt, Odense, Denmark. [3]Syddansk Universitet, Odense, Denmark. [4]Aalborg University, Aalborg, Denmark. [5]University College Copenhagen, Copenhagen, Denmark. [6]University College Absalon, Roskilde, Denmark

Abstract

The importance of continuing science teacher education is receiving increasing political awareness in Scandinavian countries recent years. This is due to a declining enrollment at science education studies. Evaluations investigating this tendency show that Danish science teachers experience the need for further skills and competencies to successfully engage and further motivate their students (Rambøll, 2018). The Danish Academy of Natural Sciences (NAFA) is therefore exploring new designs of continuing education programs. However, maybe new education programs should not be inspired purely by their local contexts and usual sources of knowledge, maybe we should also look towards other cultures and practices of continuing education for new insights and inspiration? This led us to carry out a literature review focusing on mapping international practices and programs of continuing education for science teachers. The strategy has been to investigate how different characteristics of programs in other cultures can be used to further advance Scandinavian approaches to continuing science teacher education within the structure of the Scandinavian school system and the existing culture of learning and teaching. The preliminary findings suggest that teachers across the world especially benefit from education programs with the ability to adapt to the situated context, school system and the local team culture. Implementation and sustainable organizational learning regarding continuing education seems to rely on invested time, clear communication strategies, support from management and, above all, it needs to make sense in the everyday practice of the science teachers. These findings and using them to develop new strategies of continuing science education in a Scandinavian context are what we look forward to presenting and discussing at the conference.

Parallel Session - 2.20 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Özgül Yilmaz Tüzün

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190 High School Science Teachers' Assessment Literacy for Inquiry-based Science Instruction

Ching-Sui Hung, Hsin-Kai Wu

Graduate Institute of Science Education, National Taiwan Normal University, Taipei, Taiwan

Abstract

The purpose of this study was to explore high school teachers' assessment literacy for inquiry-based science instruction (IBSI) in Taiwan. We recruited 40 high school science teachers with relevant experience in IBSI to participate in the study. Data were collected from semi-structured interviews and the background questionnaires. We analyzed the data and developed a coding scheme through both theory-orienting and data-orienting approaches. Based on Abell and Siegel's (2011) theory, this study explored science teachers' assessment purposes, assessed learning outcomes, assessment strategies and assessment scoring for IBSI. The findings were as follows. Formative purposes were most frequently used and diagnostic ones were less mentioned by interviewees. Through formative assessments, teachers supported students' inquiry-based learning and self-regulated learning in a variety of ways. Regarding the outcomes of inquiry as means, scientific knowledge, and learning attitudes and engagement were the most common. In terms of the outcomes of inquiry as ends, planning and carrying out investigations, obtaining and communicating information, and engaging in inquiry and solving problems were the most mentioned. Additionally, science teachers used a variety of data sources to assess students' learning performances. Written data, oral data and observational data were most common. Finally, teachers' scoring criteria covered students' cognitive, affective, and behavioral aspects, as well as the quality of their work (e.g., innovation and aesthetics). Based on the findings, discussions and implications are provided.

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249 Formative Assessment in the Swiss Science Classroom: What Support Do Textbooks Offer?

Regula Grob[1], Matthias von Arx[2]

[1]University of Teacher Education Lucerne, Lucerne, LU, Switzerland. [2]University of Teacher Education Northwestern Switzerland, Muttenz, BL, Switzerland

Abstract

The effect of formative assessment on student learning can be high (Hattie, 2009). However, it depends to a large extent on the implementation in classroom practice: teachers have different strategies for recognising and interpreting indications of student learning and for building

further teaching-learning processes on them (Ruiz-Primo, Furtak, Ayala, Yin & Shavelson, 2010). This aspect is augmented in Switzerland with the great freedom teachers have in designing lessons. Textbooks (Gautschi, 2017), especially at the compulsory school level, offer a means of guiding lesson design. This raises the question of the extent to which science textbooks have the potential to support teachers' formative assessment practices. It must be taken into account that support from teaching materials alone cannot guarantee the quality of formative assessment in the classroom, but that the specific implementation plays a central role (Yin et al., 2008).

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311 Assessment of Science Competencies in Primary and Lower secondary Schools

Jørgen Løye Christiansen[1], John Andersson[2], Dorrit Hansen[3], Mari-Ann Skovlund Jensen[2], Lars Bo Kinnerup[2], Jørgen Haagen Petersen[3]

[1]University College Absalon, Department of Teacher Education, Trekroner Forskerpark 4, Roskilde, Denmark. [2]University College Absalon, Department of Teacher Education, Vordingborg, Denmark. [3]University College Absalon, Department of Teacher Education, Roskilde, Denmark

Abstract

This study aims to address the challenge of assessing students' science competencies in primary and lower secondary schools in Denmark. The study employs a Design Based Research (DBR) approach, where new formative assessment designs were developed and tested in collaboration with primary and lower secondary school teachers. The intervention was guided by a common understanding of the concept of competency and an understanding of what is characteristic of competence-oriented teaching. Over a period of 13 months, 28 science teachers from 18 Danish schools participated in a one-day course on the concept of competency and three workshops focusing on inquiry, modelling, and perspective-taking competencies. The teachers shared their own lesson plans and worked with teacher educators to develop and test new assessment designs. The teachers implemented the planned lesson plans and assessment designs between workshops, and teacher educators conducted observations, recorded conversations, and interviewed teachers about their perceptions and experiences of competency-based teaching and assessment. The study findings revealed that developed rubrics and forms were useful in assessing student's science competencies and improved the teachers understanding of how to design and implement formative assessment for learning.

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653 Development of a Four-Tier Misconceptions Test About Astronomy Concepts for Assessing 6th and 7th Grades Students Knowledge

Ayşe Yildiz Tezer, Özgül Yilmaz Tüzün

ODTÜ, ANKARA, Turkey

Abstract

In the present study, a four-tier The Misconceptions Test About Astronomy Concepts (MTAC) was developed and used to assess 6th and 7th-grade students' misconceptions about astronomy concepts. MTAC was applied to 708 middle school students (360 6th grade and 348 7th grade students) during the fall semester of the 2020-2021 academic year. The four-tier test included a total of six astronomy concepts namely the planet, the sun, rotation of the Moon, phases of the Moon, eclipses, and meteor shower. Results showed that both 6th and 7th grade students had misconceptions regarding the temperature of the planet, phases of the Moon, and solar and lunar eclipse concepts. The findings of the present study might help teachers, policymakers, and stakeholders try to find better ways to help students to attain meaningful learning in astronomy concepts.

Parallel Session - 2.21 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Hye-Gyoung Yoon

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191 Development of Pre-Service Physics Teachers' Pedagogical Content Knowledge Regarding Digital Media

Rike Große-Heilmann[1], Jan-Philipp Burde[2], Josef Riese[1], Thomas Schubatzky[3], David Weiler[2]

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Abstract

As the use of educational technologies or digital media opens new possibilities for science teaching, pre-service science teachers should develop subject-specific 'digital competencies' such as pedagogical content knowledge (PCK) regarding digital media or educational technology. To foster this digital-media PCK in science teacher education, effective learning opportunities must be provided and evaluated e.g. regarding the development of digital-media PCK. In our project, we therefore developed and implemented a university teaching concept at four universities to foster pre-service physics teachers' (PSPTs) digital-media PCK. The teaching concept consists of common core elements and individual practical sessions for the respective university seminars. This study aims to evaluate these seminars regarding the acquisition of digital-media PCK and to identify conducive elements of the seminars to acquire digital-media PCK. The acquisition of digital-media PCK is investigated in a pre-post-design with a newly developed knowledge test, while the study to identify conducive seminar elements is carried out through retrospective interviews with the PSPTs after the seminars. The interviews are analysed by qualitative content analysis. The empirical evaluation of the four university seminars shows a significant increase in participants' digital-media PCK with a medium effect. The analysis of the retrospective interviews so far indicates implementing digital media in

physics teaching situations in the practical sessions of the seminar seems to promote improvements in the PSPTs' test responses. In the presentation, we will present our final results of the empirical evaluation and discuss the findings regarding the seminar elements that are conducive to the acquisition of our PSPTs' digital-media PCK.

332 Reflection on Physics Teaching: An Online-Assessment Offering Automated Feedback

Anna Weißbach, Christoph Kulgemeyer

University of Bremen, Bremen, Germany

Abstract

There is a broad consensus about the relevance of reflection on teaching and its benefits to professional development (e. g. von Aufschnaiter et al., 2019). At the same time, many studies reveal that students' reflection skills are rather low (e. g. Hatton & Smith, 1995). Accordingly, there is a need to foster the development of students' reflection skills. We present an online learning environment including a diagnostic tool, assessment feedback and supplementary material to offer systematic diagnosing, feedback and support to foster reflection skills. We evaluate the learning environment according to the argument-based approach to validation (Kane, 2013) and conduct different studies to gain insight into students' thoughts while working on the diagnostic tool or interpreting the assessment feedback. So far, the results support our validation argumentation: Students mainly think about the observed teaching and reflect on it when working on the diagnostic tool. Students' interpretation of their assessment feedback is overwhelmingly appropriate. They primarily compare their test scores to those in a comparison group. They also judge the supplementary material as beneficial for their reflection skills. Also, the resulting scale has a high internal consistency. A limitation of the learning environment, especially regarding the measurement of reflection skills, is the implementation of multiple-choice items in the diagnostic tool that enable semi-automated feedback but restrict the authenticity of the reflection situation compared to oral peer reflections.

634 Interdisciplinary Perceptions of Teacher's students: Results for a Physics and Music Intervention

Macarena Soto, Felipe Porflitt

Pontificia Universidad Católica de Chile, Santiago, Chile

Abstract

The present study shows the perception of physic teachers in formation, in an interdisciplinary intervention experience, (here in after: didactic proposal [DP]). The DP is based on a school scientific model; "modeling" (in Spanish; Modelización). To build the DP, there was a content selection in the fields of sound theory and music elements, in order to respond to a physic/music co-teaching class. Focus groups were the method to collect the data. The DP consists in two days of co-work, and the data was taken at the end of each class. Then an open

and axial coding were run, showing the following results: a) teachers in formation suggest that this kind of activity shows a change in the paradigm of physics teaching, b) modeling and interdisciplinary proposals are good learning opportunities, c) the are effects of including music in physics teaching in four transferring variables (I.e., cognitive, motor, emotion and social aspects). Also results shows emergent categories; d) link with professional practices contexts, and e) feedback for DP. Finally, as a study research team, we expect that these results can contribute to different context for physics and music teachers' formation, and for school's contexts.

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619 Characteristics of TPACK in Science Class Planning and Reflection Process: Exploring the ENA as a New Research Method

Hyun-Jung Cha[1], Seok-Hyun Ga[2], Hye-Gyoung Yoon[1]

[1]Chuncheon National University of Education, Chuncheon, Korea, Republic of. [2]National Taiwan Normal University, Taipei, Taiwan

Abstract

Amidst a growing interest in science teaching and learning in conjunction with VR/AR technology, there have been various VR/AR content for education to be developed and distributed in Korea. However, teachers in Korea are still facing difficulties in preparing and conducting science classes utilizing VR/AR. For a broad and stable use of technology in science classes, there should be research on how to improve teachers' expertise in VR/AR. Research on teachers' expertise with regards to technology utilization is mostly carried out by adopting the Technology Pedagogical and Content Knowledge (TPACK) framework. However, the existing TPACK research method s, including open-ended questionnaires and teaching performance observations, have limitations in capturing interactions between different TPACK components. In this regard, Epistemic Network Analysis (ENA) has been recently suggested as an alternative TPACK research method. This study aims to explore the details of pre-service elementary teachers' TPACK that can be found in their class plans and class reflections based on ENA. To do so, 27 pre-service elementary teachers taking the 'Science Teaching and Learning' class at a university of education in Korea were invited to participate in the study. As research data, the study collected class planning discourses, teaching guides and reports, simulation class contents, and class reflection discourses from the pre-service elementary teachers. From the class planning and reflection discourses, technology, content, and pedagogy coding frames are derived inductively which then became the basis of coded discourses to visualize connections between the TPACK components. The study found that TPACK identified during planning classes and reflecting them are different. Based on the findings, the study came up with implications to enhance pre-service teachers' TPACK abilities and possibilities and limitations of ENA in terms of the research method.

Parallel Session - 2.22 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Jaqueline Naidoo

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361 The Development of Preservice Elementary Teachers' STEM Teaching Identity: A Cross- Case Analysis

Saiqa Azam, Karen Goodnough

Memorial University of Newfoundland, St. John's, NL, Canada

Abstract

This qualitative study aimed to investigate the development of STEM teaching identity of preservice elementary teachers (PETs) during their participation in the science methods course, STEM course, and Field teaching. A case study design aimed to examine the experiences that contributed to the formation of STEM teaching identities of three PETs in a newly designed teacher education program in a public university in the Atlantic region in Canada. Data collected over a year from multiple courses included (i) questionnaire about views and perceptions of STEM, (ii) written reflection, (iii) interview transcripts, and (iv) artifacts created by PETs. Feiman-Nemser's (2008) thematic framework of learning to teach was used as an analytical lens to analyse data. The analysis of the data revealed that experiences and interactions within the science methods course, STEM course, and Field teaching accounted for the changes in how and in what ways the three preservice elementary teachers think, feel, know, and act as a teacher of science/STEM. Findings indicate the importance of the framework of learning to teach in analysing preservice science teachers' development of STEM identities. The study includes implications for preservice teacher education programs and research.

1205 Instructional Strategies Used by Physical Sciences Preservice Teachers to Facilitate Practical Work in Online Classrooms

Maria Tsakeni

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Abstract

As teachers are embracing online teaching and learning tools, they need to rethink how to facilitate some important learning activities for learners such as science practical work. Similarly, science teacher education practitioners need to rethink how to prepare preservice teachers in the facilitation of practical work both in physical and online classrooms. This study explored the strategies used by preservice teachers during practicum to facilitate practical work activities in online classrooms using an interpretive qualitative case study of one teacher preparation programme. The theory of connectivism was used as a theoretical framework. Data were collected from fifteen purposely selected final year Bachelor of Education physical sciences

preservice teachers by means of analysis of lesson plans and reflections. The preservice teachers had participated in a four weeklong learning programme on the use online teaching and learning tools for science practical work. The findings show that the preservice teachers designed different strategies and selected different tools to facilitate practical work for learners and these included, the live streaming of teacher demonstrations, the use of virtual laboratories, the use of teacher explanations and videos that showed how the experiments were conducted, use of social media to enable real time engagement and the use of work sheets and assessment. The lesson plans contained instructions given to learners on how to conduct the practical work and instructions of how to use the online tools. There seemed to be factors that influenced the choices of instructional which this recommends for further study.

78 Pre-Service Science Teachers' Perceptions of the Human Element of Science

Shingo Uchinokura[1], Daiki Yamashita[1], Hiroaki Suzuki[2], Ryugo Oshima[3], Satoshi Tsuchida[1]

[1]Kagoshima University, Kagoshima, Japan. [2]Yamagata University, Yamagata, Japan. [3]Chiba University, Chiba, Japan

Abstract

The acquisition of epistemic knowledge known as the Nature of Science (NoS) is viewed as necessary. Despite broad variance in the NoS models, there is consensus regarding the human element of science related to the image of scientists and the competence required in science. The image of scientists and science communicated through teachers is considered highly relevant to access and the current marginalisation of student groups. This study examined pre-service science teachers' perceptions of the human element of science. The participants were 156 undergraduate students (79 males, 76 females, and one student who was not specified) from four universities in Japan. All were students enrolled in a science teacher-training course, including 56 on an education bachelor course and 100 on a science bachelor course. The online questionnaire comprised four segments and 50 items, rated on a 5-point Likert scale. The four segments were the attitude towards science learning, the aptitude for different academic fields, the competencies a scientist needs, and the scientific practice in individual and social contexts. Their psychometric characteristics were scrutinised using the Rasch Rating Scale models. Altogether, pre-service science teachers have a sound understanding of some aspects of the human element of science. However, they agreed that science is more suitable for males than females, which may reflect the current gender distribution in our society. In addition, they did not share some social aspects of science: scientists work cooperatively and collaboratively, they are heavily engaged in technical communication with the scientific language, and society influences science. Further research on in-service teachers' and students' perceptions of the human element of science, NoS, is recommended, as well as the formation and transformation of their perceptions through teaching and learning.

926 Pre-Service Science Teachers' Reflections on an Acids and Bases Lesson

Jaqueline Naidoo[1], Mamothibe Thamae[2], Doras Sibanda[1]

[1]University of KwaZulu-Natal, Pietermaritzburg, KwaZulu-Natal, South Africa. [2]Durban University of Technology, Pietermaritzburg, KwaZulu-Natal, South Africa

Abstract

Acids and bases is one of the central chemistry topics taught at both schools and universities. Globally, research on teaching and learning about acids and bases in chemistry is increasingly recognised as an important field of study. In particular, there is interest in teachers' content knowledge of acids and bases, their teaching strategies as well as how students engage in learning about acids and bases and apply it to their daily lives and contexts. The aim of this study is to examine the nature of pre-service teachers' reflections after watching a video on an acids and bases lesson. Employing a qualitative, case study research design, data is analysed from 38 pre-service science teachers from four Higher Education Institutions (HEIs) in South Africa. This study adopts Toman's (2017) three levels of reflection on practice, namely, technical, application, and critical levels as the conceptual framework. Preliminary findings indicate that most pre-service teachers' reflections were technical and that pre-service teachers reflected more on the pedagogy and less on the content. It was also found that reflections of pre-service science teachers shifted across two or three levels. Implications for pre-service training of science teachers, the importance of developing critical reflection skills, and teaching of acids and bases are discussed.

Parallel Session - 2.23 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Jomo Mutegi

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762 An Examination of the Changes in Teacher Candidates' Personal Domain Throughout Collaborative Professional Development

Cigdem Han Tosunoglu, Oya Aglarci Ozdemir, Ozgur Kivilcan Dogan

Marmara University, Istanbul, Turkey

Abstract

This study examines changes in teacher candidates' science teaching orientation (personal domain) throughout collaborative professional development. The study was carried out in the context of the "teaching practice" course and the study group consists of 11 biology teacher candidates and their 4 mentors. Theoretical SSI training was organized for both groups within the scope of the professional development program, then groups were formed among the pre-service teachers and these groups developed SSI materials in cooperation with their mentors.

Interviews, pre-service teachers' diaries, and developed SSI materials were used as data collection tools for the study. The obtained data were analyzed by integrating deductive and inductive approaches. The results of the study showed that the change in the personal development areas of teacher candidates can be examined in 3 different groups. When three different groups are evaluated, it is seen that the participants in the "open-minded" group easily internalize the dimensions of the nature of SSI and apply them to their materials. Pre-service teachers in the "Explorer" group, on the other hand, were able to understand the nature and components of SSI during PD and partially integrate it into their personal science orientation. Finally, those in the "conservative" group showed limited change after PD, as they had a science education orientation that was far from the nature of SSI before PD.

772 What Does Educational Equity Mean? Views of the Harvard Teacher Fellows Program Members

Amadeu Moura Bego[1], Tarso Bortolucci Ferrari[2], Iñigo Rodríguez-Arteche[3]

[1]São Paulo State University, São Paulo, Brazil. [2]São Paulo State University, Araraquara, São Paulo, Brazil. [3]University of Alcalá, Alcalá de Henares, Spain

Abstract

The 2030 Agenda aims to achieve equitable quality education (EQE), and reform processes for teacher education can contribute to this particular goal. Science education research calls for increased efforts to clarify the conceptual dimensions associated with EQE. The aim of this work is to analyse the view of EQE held by a group of faculties and science novice teachers of the Harvard Teacher Fellows (HTF) program, together with its consistency. To this end, the technique Discourse of Collective Subject (DCS) was employed to access the Core Ideas (CI) held by the participants. The analysis of the interviews yielded 5 CI on EQE, which could be grouped into ideas related to professional practice (the most widespread ones), educational goals and opportunities. These views are aligned with the HTF's mission. However, we argue that other ideas with a more social, political character should have more prominence in science teacher education programs.

790 Modeling Competence of Pre-Service Science Teachers

Ayşe Büber

Gazi University, Ankara, Turkey

Abstract

The purpose of this study is to develop an analytical rubric for the evaluation of pre-service science teachers' modeling competencies in modeling practices. The study was carried out with 23 pre-service science teachers (PSSTs) studying in the 3rd year of a state university in Turkey. Firstly, the PSSTs had a course related to models and how to do the modeling process. Following that, four activities—"black box", conceptual, mobile technology supported, and simulation have been implemented to PSSTs to make them better understand the model types

and modeling process. Following that, an unstructured activity that includes open ended questions were given to teacher candidates to complete the activity by developing their original models. Teacher candidates worked in groups of two or three people to complete the activities. The researcher created an analytical evaluation rubric that includes three sub-categories as "Models and Modeling Knowledge", "Practice" and "Metacognitive Knowledge of Models and Modeling" to evaluate teacher candidates' models. Two experts in science education department evaluated the PSSTs' reports by using the rubric. The correspondence percentage of the experts is 79% which is a sign of inter-rater reliability. The study's findings indicate that most of the PSSTs' modeling competencies are naïve. Suggestions are made in accordance with the results.

1301 Invited NARST Session at ESERA: Prioritizing Cultural Heritage as We Strive to Become the Science Educators that Society Needs

Jomo Mutegi

Old Dominion University, Norfolk, VA, USA

Abstract

In its Science Report, Towards 2030, the United Nations Educational, Scientific, Cultural Organization (UNESCO) reports that there are 7.8 million full-time science researchers worldwide. While this number may seem large it represents only 0.1% of the world's population. As science educators we spend significant resources designing, implementing and evaluating educational experiences aimed at this small group. At the same time, the majority of the world's population does not receive educational experiences that help them to develop understandings of nature that (a) resonate with their cultural understandings of the world, and (b) help them to make informed decisions. Drawing on the theme of Connecting Science Education with Cultural Heritage, this presentation will explore ways that we can make conscious shifts in our understanding of STEM, our purpose for teaching it, and our core commitments, in order to disrupt the status quo and be the science educators that society needs.

Parallel Session - 2.24 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Theodoros Karafyllidis

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980 Pre-Service Elementary Teachers' Emotions in Implementing Science Games

Laura Martín-Ferrer, Arnau Amat

Universitat de Vic-Universitat Central de Catalunya, Vic, Barcelona, Spain

Abstract

Although games are a valuable tool for science teaching, there is still little research on the teachers' experiences in implementing games in order to construct science knowledge. This study explores how elementary PSTs make sense of their pedagogical learning experiences, during a microteaching context of implementing a scientific game activity. From an interpretative and sociocultural approach, qualitative data from the experiences of three groups of PSTs were collected from post-intervention focus groups. The results organized by three cases show that PSTs experienced moments of stress and disappointment due to students' emotional reactions to the game, as a result of; a) the misuse of the materials; b) the unclear presentation of game instructions; and c) the layout of the space. The learning context of implementing a scientific game led PSTs to reflect on the elementary students' science knowledge construction by emotional expressions that provide us insights into their orientations.

1020 Improvement of Diagnostic Competences Using Video-Supported Training Moduls - A Design-Based-Research-Study

Max Thevißen, Eva Blumberg

University of Paderborn, Paderborn, Nordrhein-Westfalen, Germany

Abstract

Due to the UN Convention on the Rights of Persons with Disabilities (United Nations, 2006), which provides the legal basis for the right of all students to participate equally in education and school, societies worldwide have been confronted with the challenge of establishing inclusive education systems. The ever-increasing heterogeneity in inclusive classrooms requires teachers with strong didactic and diagnostic skills. As one of the main subjects in primary schools in Germany, science education offers many possibilities for resource-oriented diagnosis due to its subject-specific self-image (Prengel, 2016). In order to take into account the actual needs of teachers in everyday school life and to develop a tool for improving diagnostic competence that is suitable for everyday use, the study was conceived in the sense of design-based research (Bakker 2019; McKenney & Reeves, 2019; Reinmann, 2005). In several development steps, a moodle-based tool was designed in close science-practice cooperation (Dilger & Euler, 2018) and then implemented and tested in the seminar structures of university teacher training. A video-based vignette test and supplementary scales on attitudes and self-efficacy beliefs about diagnosis in inclusive science education were used in a pre-post design in order to assess the assumed improvement in the diagnostic competence of the preservice teachers. During the lecture, the first results of the evaluation of the tool will be presented and the research work with the design-based research approach will be reported. Following the results of the study by Enenkiel, Bartel, Walz & Roth (2022), a significant improvement in teachers' diagnostic competence is expected after participation in the intervention. The results of the pre-survey will give a first insight into the existing diagnostic competences of the students

compared to the experts competences.

1160 The State of STEM Teacher Preparation: Investigation of the Intersections of Turkey and the United States

Sevil Akaygün[1], Mutlu Şen Akbulut[1], Fatma Aslan-Tutak[1], Reyhan Safak[2], Sophia Jeong[2]

[1]Bogazici University, Istanbul, Turkey. [2]The Ohio State University, Columbus, OH, USA

Abstract

Around the world, STEM (Science, Technology, Engineering, and Mathematics) education and its variants (i.e., STEAM, STREAM) are at the forefront of educational conversations. In this presentation, we as STEM education researchers in different education contexts aim to investigate the intersections of different STEM teacher preparation programs in Turkey and the U.S. Considering the international context, we engaged in dialogues and reflected on the current state of STEM teacher preparation programs and their challenges. These challenges are both localized and global to which we offer recommendations towards re-imagining STEM education.

1190 Fostering Pre-service Teachers' Understanding of Diffusion through a Modeling-based Approach

Marios Papaevripidou[1], Theodoros Karafyllidis[1], Tamar Fuhrmann[2], Zacharias Zacharia[1]

[1]University of Cyprus, Nicosia, Cyprus. [2]Teachers College, Columbia University, New York, New York, USA

Abstract

The purpose of this exploratory study was to examine pre-service teachers' development of conceptual understanding of diffusion through a modeling-based learning (MBL) approach. The participants were nineteen pre-service teachers who followed a specially designed MBL unit in the context of which they developed a series of models to explain diffusion in gases and liquids. Data sources entailed teachers' initial and final gas diffusion paper-and-pencil models (pre- and post-test), as well as initial and revised liquid diffusion paper-and-pencil models and the subsequent computer-based models. Grounded theory methods, in conjunction with a mechanistic reasoning coding scheme derived from the literature, were used for the data analysis. Three important key findings were revealed. First, teachers held non-canonical ideas about how diffusion occurs in fluids (liquids and gases) and only few of these ideas appeared as not state of matter specific; second, teachers' mechanistic reasoning advanced from the initial through their final models; and third, the computer-based modeling environment served as a facilitator of their mechanistic reasoning and scaffolded their explanations of how diffusion occurs in liquids. Findings are discussed in light of MBL potential to scaffold pre-service teachers' understanding of phenomena at the microscopic level.

Parallel Session - 2.25 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Francesco De Zuani Cassina

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512 Implementation of "Ambitious Science Teaching" Framework With Pre-Service Teachers

Francesco De Zuani Cassina[1], Michelangelo Panza[1], David Stroupe[2]

[1]University of Bologna, Bologna, Italy. [2]Michigan State University, East Lansing, Michigan, USA

Abstract

In this work, we present an example of an implementation of the "Ambitious Science Teaching" (AST) framework. The framework has been elaborated by Windschitl and colleagues from the University of Washington in 2012, to provide beginning science teachers with a set of tools for their instruction. The implementation was held by a professor who is one of the framework's authors and the first author of this proposal, between March and April 2022, with 21 pre-service physics teachers. They experienced AST from two perspectives: as teachers studying and deepening the framework and exploiting it in designing a physics teaching module, as well as students experiencing the four steps of AST in learning about a phenomenon that nobody studied in previous courses (the synchronization of coupled metronomes). At the end of the lectures, students were given a questionnaire to collect opinions about the AST framework from both perspectives (teachers/students); then we interviewed six among them to elaborate on issues raised by questionnaire analysis. The interviews have been analyzed through thematic analysis, and the codification has been triangulated between Author 1 and Author 2 in a blind process. The findings confirm other results from previous studies involving the AST framework in different settings, in terms of inclusion, safety, and agency within the scientific educational context; in addition, we found that students spontaneously developed awareness about the connection between scientific practices and the construction of citizenship skills. Though, we found difficulty in collecting information regarding the second part RQ2: this presents insights about the kind of data needed for such Research Questions, which will be addressed in future research.

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855 Scientific Literacy in Teacher Education: A Comparative Study of Turkey and Sweden

Kardelen Azra Ates, Eva Lundqvist, Jonas Almqvist

Uppsala University, Uppsala, Sweden

Abstract

In this study, we will present a cross-cultural comparison of pre-service science teachers` perspectives on scientific literacy. We investigate similarities and differences in student

teachers` perspectives and discuss how they relate to teacher education structure and culture in two countries: Turkey and Sweden. Conceptualization of science education and scientific literacy is never neutral, embedded in context and culture. Therefore, this study aims to find out how these contextual and structural differences are realized in science teacher candidates` articulation of scientific literacy. However, the definition of scientific literacy varies according to different views and approaches. In this study, three visions: Vision I, Vision II, and Vision III are used to analyze different aspects of scientific literacy that are included and excluded in the students' talk about their education. In addition to visions, seven curriculum emphases are also used as an analytical framework to investigate these differences and similarities. As there is little known about scientific literacy from pre-service teachers` perspectives in specific contexts, this study investigates different ways of conceptualizing it by involving more individual perspectives in two contexts. To study this, we conducted interviews with pre-service science teachers in Turkey and Sweden. We investigated their perspectives in terms of visions of scientific literacy and curriculum emphases. We found that in both countries scientific literacy was framed in Vision I with a little focus on Vision II whereas no articulation of Vision III was found. However, the way of describing scientific literacy showed some differences between the countries such as participants from Sweden showed a strong tendency toward biology rather than other subjects, while the ones from Turkey emphasized different subjects almost equally. The findings are discussed in terms of similarities and differences between the two countries. Lastly, practical and theoretical implications for science teacher education are addressed.

874 Territory as a Resource for Teaching and Learning in Science: Evaluation of a Training Proposal for Initial Teacher Education

Joyce Maturana[1], Erika Salas[1], Alejandra Verdejo[1], Álvaro Cañete[2]

[1]Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile. [2]Scuola Italiana, Valparaíso, Chile

Abstract

The use of territory in the subject of natural sciences has numerous benefits for students. Despite this, practising teachers often do not consider it in their practice for several reason. Here, we report the perceptions of practising teachers on the use of the territory to promote learning in formal science education. In addition, we analyze the trainee teachers planning after having taken a course in which they discussed the theoretical foundations learning outside the classroom and visited places of natural and cultural value in the city of Valparaíso, Chile. The data collected, both from the teachers' answers to open-ended questions and from the documents produced by the students were subjected to a content analysis with predefined categories. The results show that teachers do not feel supported from an administrative point of view to respond to this challenge (bureaucracy, lack of time and resources), although they recognise the lack of teacher planning. The trainee teachers see a world of educational opportunities and curricular integration in the territory, however, they tend to focus on conceptual learning, to a lesser extent on the development of skills and practically do not address the social and cultural dimension in their planning. This implies that efforts must be

redoubled in initial training so that future teachers devise authentic educational practices, with high social and cultural relevance.

1049 Identifying Microplastics in Beach Sand: Preservice Science Teachers' Use of Epistemic Criteria

Ümit Duruk[1], Emine Çavuş[2]

[1]Adiyaman University, Adiyaman, Turkey. [2]Ministry of Education, Adiyaman, Turkey

Abstract

The purpose of this study is to determine the epistemic criteria used by preservice science teachers (PSTs) during the evaluation of the process of identifying microplastics in the beach sand. 16 PSTs who were studying in the last year of the science teaching program of a state university located in the southeast of Turkey participated in the study. They were divided into four groups according to their views on the nature of science (NOS) through a scale. Data were collected by a task handout with three different scenarios for the identification of microplastics in beach sand. The data analysis is structured using qualitative content analysis. A coding framework to address each research question was used. The main findings suggest that PSTs mostly used accuracy and detail criteria while evaluating the process related to the microplastics in beach sand, they used the least replicability criteria. More importantly, compared to inadequate NOS views, having informed NOS views did not make a quantitative difference in the type and frequency of using epistemic criteria in the context of identifying microplastics in beach sand.

Parallel Session - 2.26 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Yael Shwartz

797 Durable Inclusive Instruction Among Newly Hired Secondary Science and Mathematics Teachers

Julie Luft

University of Georgia, Athens, GA, USA

Abstract

Equitable instruction is aspirational for many newly hired science teachers. Science teacher educators are responsible for their preparation, while resources within the school in which they work can reinforce their equitable instruction. This study explores the use of inclusive practices of two newly hired secondary science teachers. Both teachers participated in the same preparation program and both work in racially and economically diverse schools. In this study,

being inclusive is considered a precursor to the more complex instruction of being equitable. Furthermore, instructional practices that persist over time are viewed as durable and valued. Observations and interviews revealed that the newly hired science teachers were able to recognize some qualities associated with their students when teaching science but did not yet capitalize on the knowledge or interests students brought to the classroom nor were the students integral to the learning setting. The newly hired science teachers found their colleagues to be important in cultivating their instruction. Their colleagues were supportive and offered instructional suggestions. However, the newly hired science teachers did not indicate how various induction programs supported their use of the practices acquired during their pre-service program, nor did they indicate having readily available instructional materials to support science or inclusive instruction. This study suggests that inclusive practices are just forming in the early years of teaching science. Newly hired science teachers are able to make generalizations about student learning may be equivalent to near transfer, while embedding the complex tasks of lived experiences and allowing students to have a critical lens are more complex and equivalent to far transfer. For those of us who work with early career science teachers, it is important to consider how to cultivate and support their science instruction.

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118 Pre-school and Primary Teachers´ Professional Development in an Astronomy and Space Non-Formal Context

Isabel Borges, Isabel Chagas

Institute of Education, University of Lisbon, Lisbon, Portugal

Abstract

Space may be considered an attractive non-formal interdisciplinary learning context, involving science, technology, engineering, and mathematics. Experiences in non-formal contexts can represent a significant portion of exposure to science for Primary teachers, and non-formal science education institutions, such as museums or science centres, may provide professional development to teachers. Besides, there is a lack of studies focused on teacher professional development programs in non-formal contexts. Therefore, the purpose of this study was to appraise a science teacher professional development course offered by a network of science centres in a European country since 2016, concerning its relevance to Preschool and Primary School teachers' professional development. The European Space Agency supported the design of both the syllabus and the educational kit of the course, framed in a STEM (Science, Technology, Engineering & Mathematics) approach, promoting inquiry-based science learning on themes associated with Astronomy and Space. Participants were 196 Pre-School and Primary School teachers throughout nine editions of this course. A qualitative and interpretive approach was followed. Data collection procedures were participant observation during the course, the evaluation of individual teachers´ work, a set of 10 personal reflections, and a final questionnaire followed by content analysis and descriptive statistics. Teachers showed knowledge enhancement about the course contents and how to teach them. We detected teachers becoming aware of their misconceptions, rooted in their culture and everyday experiences, succeeding to deconstruct them and learn. In general, teachers revealed higher motivation and

enthusiasm towards science and science teaching as well as a willingness for more professional development. We are looking forward to the contribution of these results to value non-formal contexts for teacher professional development and to support better and more effective teacher education programs, improving teaching practices and raising new questions, encouraging future studies for the advancement in the field.

45 Science Teachers' Competence in Designing Argumentation Activities: An Action Research

Seda Okumuş[1], Nilüfer Okur Akçay[2], Bilge Öztürk[3], Oylum Çavdar[4]

[1]Ataturk University, Erzurum, Turkey. [2]Ağrı İbrahim Çeçen University, Ağrı, Turkey. [3]Bayburt University, Bayburt, Turkey. [4]Muş Alparslan University, Muş, Turkey

Abstract

Argumentation develops inquiry skills. The effective use of argumentation activities by science teachers in their lessons increases students' inquiry skills. In this study, the aim was to develop the skills of science teachers in designing argumentation activities. The science teachers were given theoretical and practical in-service training with action research designed in this direction. A total of 43 science teachers (34 females, 9 males) from Bursa participated in the in-service training. During the training, the teachers were first given theoretical information about argumentation. Following this, having been given two different argumentation activities with scientific and socio-scientific characteristics, they were made to distinguish between the primary and auxiliary components in the Toulmin argument model. The teachers then participated in argumentation activities linked to socio-scientific issues and produced arguments. Afterwards, examples of different activities used in the argumentation process were shown. Finally, they were tasked with designing different kinds of argumentation activities according to the achievements given in the secondary school science curriculum. At the end of the process, the participants were asked to evaluate the in-service training process. Content analysis was performed on the argumentation activities created by the teachers and evaluation form. Accordingly, the activities were examined under four themes: activity design, suitability for learning outcomes, and scientific accuracy and suitability for argumentation; later, sub-codes were created. The argumentation activities developed by the teachers had deficiencies in activity design; however, they were largely suitable for the objectives, scientifically correctly structured, and largely matched the characteristics of the argumentation activities. The vast majority of the science teacher participants stated they were satisfied with the in-service training.

106 Whatsapp Discourse: Towards Computerzied Evaluation of the Development of Teachers Professional Learning Communities

Yael Shwartz, Asaf Salman, Giora Alexandron, Zahava Scherz

Weizmann Institute of Science, Rehovot, Israel

Abstract

This two-year study followed a professional learning community (PLC) of STEM Teachers. COVID-19 pandemic accelerated changes in the focus of many professional development frameworks from face-to-face to online communication. We sought for new tools to follow the professional development and the dynamics in our PLC. We explored professional knowledge development and social interactions, as derived from a WhatsApp group (43–48 participants) discourse, before and during the COVID-19 pandemic. Data were extracted from 6599 WhatsApp messages issued during March 2019–March 2021. The analysis incorporated both structure and content examination of the PLC WhatsApp discourse, using social network analysis (SNA), and a distinctive coding scheme followed by statistical analysis and heat maps. These provided insights into whole group, subgroups, and individual profiles. The results indicated that the participants began to use the WhatsApp platform for professional purposes on top of its initial administrative intention. The pandemic enhanced professional interactions, regarding different types of professional knowledge, and accelerated the development of productive community behaviors, such as sharing and social support. Taken together, WhatsApp exchanges can serve as a rich source of data for a noninvasive continuous evaluation of group processes.

Parallel Session - 2.27 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Lynn Bryan

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782 Representation of Science and Engineering Practices in Turkish Middle School Science Texbooks

Eda Erdaş Kartal[1], Meltem Gökdaş[2], Nihal Doğan[2]

[1]Kastamonu University, Kastamonu, Turkey. [2]Bolu Abant Izzet Baysal University, Bolu, Turkey

Abstract

This study aims to examine the secondary school science textbooks in Turkey in terms of the representation of science and engineering practices. For this purpose, 405 activities were examined in 7 secondary school science textbooks used in Turkey (5th-8th grades). The document analysis method was used in the research and the data were analyzed with content analysis. The tool used in data analysis in this study is the Science and Engineering Practices Analytic Rubric (SEPAR). As a result of the research, it was concluded that science and engineering practices are not adequately represented in secondary school science textbooks. Based on the findings, it is suggested that the activities in the textbooks should be improved in terms of their level of representing the dimensions of science and engineering practices.

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908 Influence of Modeling-Based Learning on Conceptual Change in Primary Education

Julia Elsner, Claudia Tenberge, Sabine Fechner

Paderborn University, Paderborn, Germany

Abstract

As national and international studies demonstrate, primary school students can express their mental models of physics-related phenomena such as the water cycle in an external model. However, it has been shown that modeling-based learning needs to be supported at primary level. The aim of the presented study is to determine to what extent the modeling process can be supported by analogical reasoning between multiple phenomena and whether scientific concepts underlying the topic of solubility can be learned in this way. In order to achieve this goal, a study was conducted with 63 primary school students in the 4th grade. The intervention study is based on context-based learning situations on the topic of solubility of solid substances in water and oil. Both the intervention group and the control group receive the same learning situations, whereby only the intervention group is explicitly supported in analogical reasoning. In the pre-post design, knowledge acquisition is assessed with the help of interviews. Videos of the intervention and the interviews are available for the analysis. The video data is currently being analyzed with the help of a deductive category system via MAXQDA. Preliminary results show that there are primary school students who can express their ideas in the model and partially revise the models. Further results will be presented and discussed at the conference.

1071 Revealing the Work of Young Engineers: Discourse and Creativity in Early Childhood Collaborative Problem-Solving

Mia Williams, Alison Mercier

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Abstract

Young children are deeply curious about the world around them and ambitiously creative when considering real-world problems and solutions. Engaging young learners in engineering takes advantage of this innate interest and provides them with authentic opportunities to engage in collaborative, creative, problem solving. Discourse is a cornerstone of these experiences. Therefore, we explored the nature of students' discourse during collaborative engineering challenges created with an early childhood setting in mind. This qualitative study utilized assessments of children's creativity in designing real-world solutions and discourse analysis of peer-to-peer problem-solving. We outline features of young children's creativity and highlight connected patterns of problem-solving discourse.

1088 Human Modeling as an Ideational Resource in Kindergartener's Learning About Matter

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[1]Purdue University, West Lafayette, IN, USA. [2]Oakland City University, Oakland City, IN, USA

Abstract

In this study, we explored kindergarteners' enactment of the nature of matter (solids, liquids, and gases) as they engaged in a discourse-rich, modeling-based inquiry lesson on states of matter. Through an iterative process of model elaboration, model refinement, model sense-making, and model application, children engaged in investigations to explore the relationship between the macroscopic and microscopic properties of states of matter. One of several types of modeling activities in the lesson consisted of "human modeling" in which children embodied particles that make up matter and enacted a specific state of matter. Thus, in this study, we were interested in how kindergarten students elaborate particle models as they enact them through embodied actions. Specifically, we sought to understand how children represent their understanding of microscopic and macroscopic properties of matter. A total of 72 kindergarten children and four teachers in a midwestern U.S. elementary school participated in the study. The data sources for this study included videotape recordings and their transcriptions of the class sessions in which children engaged in human modeling activities. A coding scheme was developed by using cognitive science bootstrapping technique of iterative "bottom-up approach" analysis (Chi, 1997, Samarapungavan et al., 2017). The results overall showed that the kindergarten learners were able to accurately enact simple particle models to demonstrate the macroscopic properties (shape, positioning) and microscopic properties (arrangement and relative distance) of each state of matter and the microscopic movement properties (movement, speed, trajectory) of solids, but had difficulty representing the microscopic motion properties of liquid and gas phases.

Parallel Session - 2.28 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Ruth Yañez

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103 Teacher Questions in Secondary Biology Classrooms: Making Scientific Practices Meaningful for Students

Zhongyan Zhang

University of Leeds, Leeds, United Kingdom

Abstract

The purpose of this study is to find out how teachers use questions in secondary biology classrooms to engage students in scientific practices. The study was conducted in large-class settings, three grades, and four schools in one city in mainland China. Purposes of teacher questions were developed inductively, including purposes related to scientific practices, use of questions to emphasize social responsibility, and use of questions to support understanding big ideas in science. Teacher questions are affected by personal, internal, and external factors. The findings show the reasons why a teacher asks a type of questions or a sequence of questions and what might be driving that. This research also considers how teachers make great efforts to select and adapt drawings, gestures, teaching materials or resources to support their questioning and scientific practices when they polish their lessons. Students' views about different types of teacher questions and what they notice about teacher questioning are discussed.

785 Narrative Writing About Fictional Animal Evolution Following the Game-Play Darwinium

Magali Coupaud[1], Fabienne Paulin[2], Alice Delserieys Pedregosa[1]

[1]AIX Marseille University, Marseille, France. [2]Université Lyon 1, Villeurbanne, France

Abstract

The communication is based on the integration of the board game Darwinium in a biology class in lower secondary school in France. The game, designed by a team of researchers and teachers, engages students to observe the evolution of fictional animal populations. It aims to model different ideas of chance in an evolutionary process. Students are engaged in narrative writings after a game-play. From the analyses of these writings we identify student's expression of ideas about chance and evolution and how they connect to the narrative of the game. For some students, there is an understanding of certain important ideas of evolution (variability, chance, environmental pressure).

893 Acceptance of Evolution by Israeli Students from Diverse Religious Groups

Netta Dagan[1], Masha Tsaushu[1], Rachel Pear[2], Nigmeh Kadan-Abu toameh[2], Hanan Alexander[2], Tali Tal[1]

[1]Technion - Israel Institute of Technology, Haifa, Israel. [2]University of Haifa, Haifa, Israel

Abstract

Evolution is a compulsory topic in the biology curriculum for the secondary schools in Israel. Yet, students' achievements in evolution questions in the biology matriculation exams are not satisfying. Prior research showed that theological issues undermine the learning of evolution. Therefore, our research question is: what is the acceptance rate of evolution among secondary school students from various religious groups in Israel? We analyzed students' responses to the

MATE questionnaire, translated to Hebrew and Arabic (N=1028). We found differences between school streams and levels of religiosity. There were significant differences between secular Jewish (highly acceptance of evolution), and all other groups (religious Jewish, Druze, Muslim). In addition, religious Jewish students showed less acceptance of the scientific view about the age of the Earth, although they supported statements about non-contradiction between evolution and faith. Understanding students' views and challenges with learning about evolution is a part of "sensitive teaching" that enables teachers to cope with students' difficulties. This approach could contribute to the development of culturally responsive learning materials that address student difficulties and contribute to students' understanding and higher acceptance of evolution as well.

1090 Pre-Service Science Teachers' Collaborative Learning from the Cultural Historical Perspective of the Theory of Activity: A Case Study

Ruth Yañez, Carol Joglar

Universidad de Santiago, Santiago, Chile

Abstract

Currently, teachers face great challenges when designing and planning teaching, which must respond to the demands of educational policies and standards of the teaching profession from the perspective of professional development. In this sense, initial teacher training must also meet the expectations of knowledge, skills and attitudes expected of a Pedagogy graduate (CPEIP, 2021). Therefore, it is necessary that there are support and response devices to respond to these demands in teacher training and professional development of practicing teachers (Darling-Hammond et al., 2017). Several studies point out that to respond effectively to these demands collaborative work is presented as a fundamental strategy because it is a space in which converge what the teacher, knows, knows about and about his own practice, contextualized and situated (Borko, 2004). To address this challenge, the co-design or collaborative design approach is presented as a working device in which a human group that may or may not belong to different areas of knowledge make a reciprocal and common effort to respond and/or find solutions that satisfy all stakeholders (Fontana, 2012). In this paper, we seek to describe and explain the learning of pre-service science teachers in the context of their professional practice by identifying different levels of contradictions when they collaboratively design teaching proposals and then implement them in the classroom of the educational center.

Parallel Session - 2.29 (Oral Presentations)

17:00 - 18:30 Monday, 28th August, 2023

Chair: Anna-Vera Meidell Sigsgaard

144 How Does Peer Tutoring Affect the Perceived Quality of Teaching from the Perspective of the Tutees?

Jonas Tillmann, Claas Wegner

Osthushenrich-Center for Gifted Research at the Faculty of Biology (OZHB), Bielefeld, Germany

Abstract

Getting students interested in computer science and technology at an early age is a declared goal of the satellite laboratories. Following a cross-age peer tutoring approach and using the physical computing platform, students from the 5th grade onwards can discover the diversity of computer science and technical topics. Based on the characteristics of physical computing and the method of discovery learning, teaching units were designed considering didactic-methodical and content-related decisions, which are carried out by tutors (students from the 9th grade onwards) in the satellite laboratories. Teaching is characterized by complex constellations of features, and peer tutoring represents a special teaching approach which does not necessarily lead to effects such as interest and joy of learning in the teaching-learning process. The impact depends on the quality of the tutors' instruction and the extent to which the instructional interventions are perceived or used by the learners at all. In this study, 13 students were interviewed using guided interviews to examine individual aspects of the quality characteristics of teaching in the satellite laboratory and to work out the potential of cross-age peer tutoring within the school. The results of the qualitative content analysis show that an informal learning atmosphere is created in the satellite laboratories, in which the students can try out a lot under no pressure to perform. Explaining things at eye level is rated as positive. Teaching in teaching teams is a great advantage, so that the tutors can support each other. Nevertheless, there are some potentials for development to increase the quality of teaching within the satellite laboratories.

367 Secondary School Students' Reflection on the Usage of Tasks From the Biology Olympiad in Biology Lessons

Matěj Novák

Department of Biology, Faculty of Education, University of South Bohemia in České Budějovice, Czech Republic

Abstract

Tasks from the Biology Olympiad (BiO) seem to be a suitable alternative to teaching tasks in biology lessons to increase the number of opportunities for students to work with inquiry tasks

during school activities because they often contain elements of inquiry. But for teachers to be able to integrate BiO tasks into their lessons without fear, it is necessary to know what is the most difficult for the students during their solution. Therefore, during the biology classes were used tasks from the BiO. Then through a questionnaire, it was found out that the students had the biggest problem with individual inquiry activities (observation, comparison, and description of observed events) and that a major part of the participants perceived the inclusion of BiO tasks in biology lessons positively. This means that students do not work enough with inquiry tasks during the teaching process, and the usage of BiO tasks could be a way to improve the students' inquiry skills during biology classes.

505 Semantic Waves & Linguistic Snails: Teaching Science With Legitimation Code Theory and Systemic Functional Linguistics

Anna-Vera Meidell Sigsgaard, Ditte Marie Pagaard, Sonja Heinrich, Dorte Maiken Lohse, Suzanne Schjøtt

University College Copenhagen, Copenhagen, Denmark

Abstract

This paper reports on an educational research and development project in progress. The project aims to make science lessons in the Danish middle-year grades (4-6) more accessible to all students by increasing science-teachers' awareness of the linguistic challenges second language learners in particular (can) encounter in science lessons and materials. The aim of the paper is to demonstrate teacher-development and strategies for making 'science knowledge' visible to all students by integrating meaningful language work in science lessons. The project takes its point of departure in an understanding of students' learning where linguistic interactions are seen as crucial for accessing scientific understandings. In the paper we introduce an analytical approach using semantic waves from Legitimation Code Theory (LCT). Observations and transcriptions of conversations from 4th grade science lessons provide data for semantic gravity analysis, which leads to discussions of how awareness of semantic waves can encourage teachers to integrate language activities in science lessons in order to scaffold their students' science understandings and participation.

673 Rationales for the Strategies Used by Science Teachers While Teaching 'Variables That Affect the Brightness of a Light Bulb'

Şeyma Irmak[1], Duygu Yılmaz Ergül[2], Elif Yalvaç Ertuğrul[2]

[1]Amasya University, Amasya, Turkey. [2]Gazi University, Ankara, Turkey

Abstract

This research aims to reveal science teachers' strategies while teaching the topic "Variables That Affect the Brightness of a Light Bulb in a Simple Electrical Circuit" and the rationales for preferring these strategies. Semi-structured interviews were conducted with eight science teachers working in different cities of Turkey with between three and twelve years of

experience. In addition, the data was deepened with card sorting activity and mimic form. The obtained data were divided into themes and categories by content analysis. The results of the study showed that science teachers often prefer to use dialogical strategies within the scope of micro strategies for rationales such as classroom management, lack of materials, low levels of readiness of students, anxiety of not being able to teach the curriculum on time, and limited course time while teaching the topic. Although the teachers stated that experimentation is effective in providing permanent learning and enhancing learning, due to these rationales, they either perform demonstrations or use direct instructions, question-answer, concept maps, and real-life examples, which include mental activities for students to understand the causal and functional mechanism of the topic. These results show that external instructional strategies such as STEM and modelling, which are revealed to increase both the academic success and higher-order thinking skills of the student, are not used for various rationales in the teaching process.

Parallel Session - 3.1 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

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12 The Family Resemblance Approach: A Framework for Science Education Research

Chair

Miri Barak

Discussant

Sibel Erduran

Abstract

The Family Resemblance Approach (FRA) is a pedagogical and methodological framework that has been applied to various aspects of science education to provide an inclusive vision of the nature of science (NOS). Grounded in the work of Irzik and Nola (2011), the FRA depicts 'science' as a family of disciplines that share similar aspects, but also differ in nuanced approaches to each aspect. In commemoration of Prof. Nola, the symposium provides a platform for discussing recent applications of FRA from multiple perspectives and from an array of countries: Norway, UK, Turkey, UAE, and Israel. The first paper explores how an episode from the history of the thermometer can serve as context for teaching high-school chemistry students about NOS, and particularly the 'aims and values' in science. Literature in history of science, philosophy of science, use of narratives and the performative paradigm feed into a hermeneutical spiral, where a teaching unit was developed and tested. Data analysis invoked the concept of "research with", arguing that historical episodes with use of the FRA allowed for complexity and context to support students' own creation of NOS. The second paper explores the way preservice science teachers depict and develop their trajectory of NOS understanding through the use of FRA-related learning activities. The study examined participants' drawings and written explanations, indicating a significant increase in the number of participants who associated NOS with scientific practices, methodological rules, scientific knowledge, and scientists' professional activities. The findings identified a shift in preservice science teachers' NOS understanding from a stance based on learners' perspective of asking everyday questions towards a scientist perspective with a social-institutional viewpoint. The third paper explores science teachers' views on inclusion of NOS in school science textbooks and the harmony between the teachers' views and the textbook analysis results. Through the application of the Reconceptualized Family Resemblance Approach to NOS (RFN), the study identified missing categories and those that are insufficiently integrated in the textbooks, along with the need to increase teachers' awareness of NOS representation in textbooks. Adding to this idea, the fourth paper explores how RFN can be used to enhance science teachers' understanding and teaching of NOS with young children. The paper presents an analysis of the science curriculum and NOS understanding of teachers, with implications for RFN-based workshops, highlighting

the interrelations between sciences and the defining aspects of NOS in a holistic manner. Overall, the symposium will engage participants in a timely and contemporary conversation on FRA and its applications in the investigation of NOS understanding, the design of teacher education programs, and the analysis of curricula and textbooks. Following the symposium, we hope to generate a community of researchers who are interested in pursuing this important line of work.

53 Preservice Science Teachers' Depiction and Development of Nature of Science Understanding

Miri Barak[1], Tal Yachin[1], Sibel Erduran[2]

[1]Technion, IIT, Haifa, Israel. [2]University of Oxford, Oxford, United Kingdom

Abstract

While research on NOS is fairly substantial, emphasis on NOS understanding from a holistic stance is still under debate. One way of providing an inclusive vision of the NOS is through the Family Resemblance Approach (FRA). Thus, the goal of this study was to examine the way preservice science teachers depict and develop their trajectory of NOS understanding from the perspective of the FRA. Appling the dual-analytic approach, the study examined participants' drawings and written explanations, before and after participating in a course entitled: 'methods of teaching science and technology in middle school' that incorporated FRA-related activities. The findings indicated a significant increase in the number of preservice science teachers who associated NOS with scientific practices, methodological rules, scientific knowledge, and scientists' professional activities. The findings identified a shift in preservice science teachers' NOS understanding from a stance based on learners' perspective of asking everyday questions towards a scientist perspective with a social-institutional viewpoint.

55 Teaching Nature of Science in High-School Chemistry: Inviting Students to Research With Henri Regnault

Madelene Losvik Berntsen, Camilla Berge Vik, Annette Lykknes

Norwegian University of Science and Technology, Trondheim, Norway

Abstract

In this paper, we explore how an episode from the history of the thermometer can serve as context for teaching high-school chemistry students about Nature of Science (NOS), and particularly aims and values in science. We immersed in the story of Henri Victor Regnault (1810-1878) and his contributions to the choice of thermometer fluid as the starting point. The study takes form as a hermeneutical spiral. Literature in history of science, NOS, the Family Resemblance Approach (FRA), science education, philosophy of science, use of narratives and the performative paradigm feed into the spiral along with input from an empirical study where a teaching unit (n=21, duration 90 minutes) was developed and tested, and a thematic analysis

of students' statements (n=13) carried out. Invoking the concept of "research with" from the performative paradigm, we argue that the historical episode with use of the FRA 1) invited students to identify with the human actor; 2) helped highlight narratives and thus invited students into the historical context; and 3) allowed for complexity and context to support students' own creation of NOS.

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56 How Science Teachers' Views on Inclusion of Nature of Science in the Textbooks are in Line With the Textbook Analysis Findings?

Beyza Okan, Ebru Kaya

Bogazici University, Istanbul, Turkey

Abstract

Reconceptualized Family Resemblance Approach to NOS (RFN) is one of the recent NOS frameworks defining science as epistemic, cognitive, and social-institutional systems. This study which is a part of a funded project examined the science teachers' views on inclusion of nature of science in the middle school science textbooks and the harmony between the teachers' views and textbook analysis results. Knowing how the nature of science is represented in textbooks may make it easier for teachers to integrate these ideas into their science classrooms. Accordingly, they may include textbooks in their classes in different ways or they may understand that they need additional teaching materials to teach NOS. For this purpose, 4 science textbooks which were selected purposively were examined based on RFN and 8 science teachers who use those textbooks actively in their classrooms were selected conveniently to conduct interviews. Through the content analysis, some existed keywords were traced in each sentence and some general meanings were examined from the paragraphs, activities, figures, and tables of textbooks. It was found that even though there are some references to each NOS category, their representations are limited when we consider how RFN defines each category. The thematic analysis of teachers' views generally supported the textbook analysis results. The teachers stated that most NOS categories are missing or insufficiently included in the textbooks. However, for some categories their views are different from textbook analysis result. Based on the results it can be said that generally the teachers' views are in line with the textbook analysis but the awareness of the teachers on how each NOS category is represented in the textbooks should be increased. Teacher training programs may be planned to improve teachers' NOS conceptions. Thus, they may evaluate the textbooks on this issue as expert effectively.

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57 The RFN as a Theoretical and Methodological Framework for Research in Science Education: Highlighting Early Years Teaching and Learning

Hassan Tairab[1], Rachel Takriti[1], Sibel Erduran[2], Lutfieh Rabbani[1], Iman AlAmirah[1], Olga Iaonnidou[3], Hala Elhoweris[1], Najwa Alhosani[1], Lindsay Schofield[1]

[1]United Arab Emirates University, Al Ain, UAE. [2]University of Oxford, Oxford, United Kingdom. [3]University College Dublin, Dublin, Ireland

Abstract

RFN has been utilized as a framework for understanding NOS across many different contexts of education and practice. However, research into NOS in science teaching and learning in the early years has not been a focus on interest despite evidence on the importance of the foundation years in setting the scene for future learning and development. In the United Arab Emirates (UAE), science and science education is held in high regard, forming part of the national agenda. This paper describes the SciKids Project, an innovative research project, in the UAE, examining how RFN can be used to enhance early years teachers' understanding and teaching of NOS with young children. The paper presents a brief analysis of the current curriculum, analysis of the NOS understanding of pre and in-service teachers, a description of the development and translation of the RFNQ into Arabic (RFNQ-AR), and a discussion of CPD workshops for early years teachers and the impact of these on the understanding of NOS.

Parallel Session - 3.2 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

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21 Challenges and Opportunities of STEM Education– Bridging Science, Practice and Policy in Europe

Chair

Gokhan Kaya

Discussant

Agueda Gras-Velazquez

Abstract

Europe is facing teacher shortages. STEM education systems lack the capacity to support teachers regarding their professional development. This is exactly where the 3C4life project comes in. 3C4life supports to change that image and the establishment of educational systems which allow STEM teachers to operate successfully along their whole career paths. In order to raise the attractiveness of teacher profession a positive image of the teaching profession is required. The use of innovative teaching approaches and the establishment of professional learning communities have established three central approaches within STEM education: cooperation, career possibilities and competence development. To enhance cooperation between different stakeholders, the ESERA conference offers a particular symposium set up as an international policy seminar to reflect and exchange experiences in regarding challenges and opportunities of STEM education. The main aims are to:

- Present best practice examples from science, practice and policy regarding the most impactful dimensions in STEM education

- Illuminate the approach and implementation of career possibilities, collaborative practices and competence development in STEM education
- Discuss and reflect on various questions concerning challenges and opportunities of STEM education in Europe

562 Competence Development in STEM Education: How to Promote Teachers' Learning?

Mónica Baptista[1], Iva Martins[1], João Paulo Castro[1], Nuno Dorotea[1], Ana Luísa Alves[2], Maria Nabais[2]

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Abstract

STEM Education facilitates the development of students' transversal competencies, such as critical thinking and problem solving, based on the use of inquiry-based learning (IBL), authentic contexts (AC) and socio-scientific issues (SSI). However, many variables affect how teachers use and implement STEM activities in their classroom, in order to promote students' competencies development. For examples, teachers may experience difficulties in interpreting and understanding the intentions of the STEM Education, sometimes have limited views on IBL, AC and SSI. In order to inspire teachers for STEM teaching and also for STEM careers, the 3C4Life project developed a platform of collaboration and exchange (Teach4Life) that offers attractive career options for STEM teachers, as well as STEM materials and resources that facilitate students' competence development, through inquiry-based learning, authentic contexts and socio-scientific issues. The goal of the present study was to examine what STEM teachers learn about competence development in STEM education, namely regarding the nature of the IBL, AC and SSI when they participate in professional development program that used Teach4life platform. The present paper is based on a preliminary study conducted within the context of the project 3C4Life. The participants of this study were 164 in-service teachers, attending a professional development program. The results show that teachers learned to identify the characteristics of IBL, AC and SSI and acknowledged the potential of using Engineering design processes in the classroom. Teachers also recognized that the open nature and the high level of challenge of STEM resources and materials allowed students to develop their understanding of scientific concepts and processes, autonomy, reasoning skills, creativity and communication. Teach4life platform supported teachers learning to identify the characteristics IBL, AC and SSI and understood its importance for students STEM competences development.

646 Bridging Research Practice and Policy to Improve Stem Learning Through Teacher Professional Development

Antonio Quesada[1], Marta Romero-Ariza[1], Ana María Abril[1], María Martín[1], Oscar Lozano[2]

[1]Department of Science Education. University of Jaén, Jaén, Spain. [2]CEFIRE Cientific Tecnologi i Matemàtic., Valencia, Spain

Abstract

Science and technology are essential tools to expand humans' capacity to address current environmental and societal challenges. Therefore, STEM education becomes essential not only to generate highly qualified professional in the STEM fields, but also, to educate STEM-literate citizens. Teachers are key players in the transformation of society through education, so STEM teacher career and teacher professional development should be at the center of any effort to generate knowledge-based and STEM-literate societies. However, international reports showed low social recognition and motivation for the teacher career and the need to better support teachers' capacity to address current challenges in STEM education, fostering their professional development and growth in communities of practice. Based on all these considerations, this work presents a national experience within an international project aimed at fostering teaching competences to enhance STEM learning, teachers' knowledge and motivation for their career and a positive attitude towards collaboration within communities of STEM teachers. A special emphasis was placed on bridging research, practice and policy as a way of providing research-base and systemic, setting a strong collaboration among STEM education researchers, teachers and institutions responsible for teacher professional development and keeping teachers' needs and the actual curriculum as main referent points in the process. This work describes the tools and the intervention developed to achieve the intended goals and the process of development of research instruments to evaluate the impact of the intervention. In particular, the research instruments have been designed to measure changes in teacher' perceived relevance of and motivation for the teaching career, their perception of teacher collaboration and community building, their views about competence development and self-efficacy and their knowledge about the different career pathways they can navigate to shape their best personal path as a teacher.

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274 Being a STEM Teacher as a Career Choice

Gökhan Kaya[1], Metin Şardağ[2], Gultekin Cakmakci[3]

[1]Kastamonu University, Kastamonu, Turkey. [2]Van Yüzüncü Yıl University, Van, Turkey. [3]Hacettepe University, Ankara, Turkey

Abstract

The shortage of STEM teachers in Europe is reflected in reports as an increasing situation. In addition to the decrease in the number of people choosing STEM teaching fields, the shift of teachers' careers to other areas is also seen as a problematic issue. Although career choice is seen as an individual decision, the individual's life, social environment, culture, knowledge,

skills and attitudes developed since infancy play an essential role in the individual's career choice. This study aims to reveal the factors affecting STEM teachers' career choices. For this reason, it shows the structures that lead STEM teachers to become teachers through the discourse analysis method and the career stories of STEM teachers obtained within the 3C4Life project. According to the first findings obtained, structures such as the opportunities provided by the family during childhood, time spent in nature, and teachers in STEM fields encountered in school are related to becoming a STEM teacher. The results obtained from the study will likely affect policies and policymakers regarding teacher education and investing in human capital. The result will be discussed concerning policy issues in line with our project and the EU.

1175 Prospects of Career Possibilities, Collaborative Practices and Competence Development

Brett Langenberg

Futurum Careers, Bristol, United Kingdom

Abstract

Europe is facing teacher shortages. STEM education systems lack the capacity to support teachers regarding their professional development. This is exactly where the 3C4life project comes in. 3C4life supports to change that image and the establishment of educational systems which allow STEM teachers to operate successfully along their whole career paths. In order to raise the attractiveness of teacher profession a positive image of the teaching profession is required. The use of innovative teaching approaches and the establishment of professional learning communities have established three central approaches within STEM education: cooperation, career possibilities and competence development. To enhance cooperation between different stakeholders, the ESERA conference offers a particular symposium set up as an international policy seminar to reflect and exchange experiences in regarding challenges and opportunities of STEM education.

Parallel Session - 3.3 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

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13 Systems Thinking in Science Education

Chair

Moritz Krell

Discussant

Marie-Christine Knipples

Abstract

In science education, systems thinking (ST) is a way to understand, explain and interpret complex and dynamic phenomena, a learning strategy that explicitly considers system characteristics to explain and predict natural phenomena. ST is widely acknowledged as a fundamental goal in science education, the development of which is necessary for a coherent understanding of complex processes and phenomena. Recent reviews suggest that ST is an emergent and growing research topic in science education. This symposium brings together four contributions on ST in science education. The contributions focus on different target groups and adopt different methods to investigate ST. The first contribution is a bibliometric analysis and research synthesis on ST and complexity in STEM education. The contribution presents emerging trends and identifies research gaps related to ST in science education. One finding is that the majority of studies on ST focused on higher education and biology. The second contribution presents the development of a learning performance for primary students' ST skills about energy flow. The authors present a fine-grained analysis of students' system models and identify milestones in developing primary students' ST skills. The study suggests that students require additional scaffolding to conceptualize relationships when energy spans two large systems and energy cycles that exist within and across the energy systems. The third contribution is a content analysis of biology textbook tasks on ST in the context of the carbon cycle. Based on a qualitative analysis of German textbooks, the author found the ST skills "identifying system organisation" and "analysing system behaviour" are more frequently addressed than "system modelling." The selection of entities and activities of the carbon cycle in the tasks depicts a variety of individual aspects. Still, it often does not allow us to trace dynamics in the carbon cycle along carbon flows continuously. The fourth contribution presents a study on high school students' ST progression in a nanosatellite engineering program. The authors present case studies and use the repertory grid technique to investigate ST development throughout the program. The findings indicate that students who stayed focused on a single satellite subsystem showed limited progress, while students who involved themselves with several subsystems exhibited more meaningful progress. Although the program design aimed to assign students to a narrow role to enable them to achieve their educational goals, this was counter-productive from the perspective of ST. The bibliometric study (contribution one) presents that most studies target higher education. To address this gap during the symposium, other contributions emphasize addressing or implementing ST at different grade levels (including primary and secondary school students), in three disciplines (science, biology, engineering), and in various contexts. The three empirical studies, in sum, present valuable insights. For example, bringing together findings of contributions two, three, and four, the symposium shows that students often lack an understanding of dynamic relationships within systems as well as relationships between different (sub-)systems (contributions two and four). These skills seem to be seldom addressed by textbook tasks (contribution three). Furthermore, contribution four suggests that there might be a trade-off between achieving the educational goals of a curricular program and fostering students' complex ST skills. In sum, the symposium represents the diverse disciplines in which ST is necessary to understand, explain, and interpret relevant phenomena and the various research methodologies to grasp ST. The panel will discuss how ST can be implemented in other

disciplines to move forward. Participants will have the opportunity to discuss the role of ST in science education, the most promising research directions of the field, and how teachers and students can be supported in developing their ST skills.

258 A Bibliometric Analysis and Research Synthesis on Systems Thinking and Complexity in STEM Education

Ibrahim Delen[1], Tom Bielik[2], Orit Ben-Zvi Assaraf[3], Moritz Krell[4]

[1]Usak University, Usak, Turkey. [2]Beit Berl College, Beit Berl, Israel. [3]Ben-Gurion University, Ben-Gurion, Israel. [4]Leibniz-Institut für die Pädagogik der Naturwissenschaften und Mathematik an der Universität Kiel (IPN), Kiel, Germany

Abstract

Understanding complex systems has become a prominent aspect of STEM education in recent years. Systems thinking plays a critical role, focusing on system attributes such as interactions between components, boundaries of the investigated system, emerging phenomena, and hierarchical organisation. In this study, we provide a bibliometric analysis and a comprehensive review of empirical studies on systems thinking and complexity in STEM education from the past two decades. We reviewed 255 empirical studies and found a sharp increase in the number of studies on systems thinking after 2016. We categorised these studies under the categories: study population, disciplinary field, system attributes, and cognitive aspects. Most studies focused on higher education and biology, while few studies focused on pre- and in-service teachers. Complexity and interactions emerged as the most mentioned system attributes, while understanding and thinking were the most mentioned cognitive aspects. While reporting the discrepancies in terms of the categories mentioned above, our review also serves as a baseline to understand emerging trends and identify research gaps and directions for future studies.

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69 Development of a Socio-Ecological Learning Performance for Primary Students Systems Thinking Skills about Energy Flow

Laura Zangori[1], Laura Cole[2], Sepideh Fallahhosseini[1], Suzy Otto[1]

[1]University of Missouri, Columbia, MO, USA. [2]Colorado State University, Fort Collins, CO, USA

Abstract

Systems thinking does not develop without purposeful intervention. We designed a 10-week middle school social-ecological unit about energy flow in which we purposefully embedded systems thinking supports across the unit. Students developed systems models throughout the unit to make their thinking about energy flow in a large socio-ecological system visible to themselves, their teachers, and to us. We used their pre/mid/post-systems models to empirically ground a learning performance to examine students' systems thinking development about energy flow across the unit.

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61 A Content Analysis of Systems Thinking in Biology Textbook Tasks on the Carbon Cycle

Katharina Düsing

IPN – Leibniz Institute for Science and Mathematics Education, Kiel, Germany

Abstract

To understand the global cycling of carbon is critical for an informed participation in the current public discussion on climate change. To reach this goal, promoting systems thinking is central. Textbooks still represent the primary learning tool in biology classes, but research-based information is currently lacking regarding in what way students work on acquiring systems thinking skills when solving textbook tasks on the carbon cycle. Therefore, this study investigates two research questions: (1) Which systems thinking skills are addressed in textbook tasks on the carbon cycle? and (2) In what way do students engage with entities and activities of the carbon cycle from different levels of biological organisation when working on the tasks? The second research question relates to the argument that the multi-level character of the carbon cycle causes particularly learning difficulties for students. Following a qualitative content analysis, two coding schemes are developed and applied. Main results are: the systems thinking skills "identifying system organisation" and "analysing system behaviour" are more frequently addressed than "system modelling". The selection of entities and activities of the carbon cycle in the tasks depicts a variety of individual aspects but often does not allow to continuously trace dynamics in the carbon cycle along carbon flows. It is suggested that tasks on the carbon cycle should place more focus on system modelling and that the selection of entities and activities should support knowledge integration.

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282 Systems Thinking Progress in Engineering Programs: A Case for Broadening the Roles of Students

Ram Tamir[1], Orit Ben-Zvi Assaraf[1], Shimrit Maman[2]

[1]School of Education, Ben-Gurion University of the Negev, Be'er-Sheva, Israel. [2]Homeland security institute, BGU, Be'er-Sheva, Israel

Abstract

Complex systems are prevalent in many scientific and engineering disciplines, making systems thinking important in these fields. Duchifat 3 is a unique project-based program, where high school students designed, assembled, and tested a nanosatellite, while exploring in teams, various aspects of the satellite's design. This study is aimed at exploring how the participants' systems thinking developed throughout the program. We applied qualitative methods using the repertory grid technique, semi-structured interview at the beginning and at the end of the project, and observations. Systems thinking in the context of a satellite project proved challenging for students, despite the fact that the program afforded them abundant opportunities to deal with complex systems. Students who chose to be involved with more aspects of the program or conducted a research project exhibited more progress in their

systems thinking. Students who stayed focused on a single subsystem showed limited progress, while students who involved themselves with several subsystems exhibited more meaningful progress. Although the program design aimed to assign students to a narrow role to enable them to achieve the educational goals, from the perspective of systems thinking this was counter-productive.

Parallel Session - 3.4 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

9 Symposium on Collective Activism to Address Socially Acute Questions in Science and Technology Learning

Chair

Daniel Cebrián-Robles

Discussant

Ralph Levinson

Abstract

Today we are confronted with a number of globally interconnected and locally specific problems such as climate change, food quality and safety, COVID-19, etc. Many of these are interrelated or result from scientific and technological activities, globalisation processes and economic, political, values and ethics (Adams et al., 2018). But today's society faces not only complex social and environmental problems, but also setbacks in human rights, social justice and the well-being of people, societies and the environment (Reis, 2021). To respond to the challenge of this situation, educational institutions must become agents of change, enabling a shift to citizen action and engaging students in social, environmental, political and economic justice issues (Bencze and Alsop, 2014; Hadjichambis et al., 2020). Furthermore, it should be borne in mind that these problems are present in the media and social networks, where an excess of information/disinformation circulates, which challenges teachers to try to counteract this perverse influence on citizens and society (Osborne et al., 2022). For Hodson (2003), scientific literacy must go beyond the transmission of science-related knowledge and train citizens to make responsible decisions and move on to socio-political action on social and environmental problems at local and global levels, using scientific and technological knowledge. Legardez and Simonneaux (2006) propose to bring these citizenship-relevant problems and accompanying controversies into the classroom as socially acute questions, given the variety of interests at stake, and requiring responsible decision-making for citizen action (Bencze et al., 2020). This symposium presents papers that focus on the collective activism approach to science and technology education by addressing problems relevant to citizenship as socially acute questions. The papers presented aim to identify the complexity of

these issues in order to analyse them before proposing and implementing actions involving solutions for change.

305 Nature of Science in the Analysis of News on Socially Acute Questions for Collective Activism

Francisco José González-García, Paloma España-Naveira, Aurelio Cabello-Garrido, Enrique España-Ramos, Daniel Cebrián-Robles, Isabel María Cruz-Lorite, Ángel Blanco-López

Malaga University, Málaga, Spain

Abstract

The severe deterioration of the planet by human action, social injustice and the rollback of democratic rights largely characterise today's world. Another characteristic is disinformation, which is directed at emotions and beliefs to make rational or reasonable explanations difficult. In this context, we are developing a training proposal on activism that starts from an initial problem statement related to a controversy about a socially acute question from which a process of enquiry is developed that includes: 1) analysis of the controversy through the cartography of controversy approach, 2) search, selection and analysis of information about the problem/controversy and 3) proposals for action in relation to the resolution of the stated problem and its implementation. In order to help citizens to understand science-related news better, identify and reject fake news and critically trust science, we focus in this paper on the first phase of the process of designing a news analysis tool based on a broad nature of science approach. This first phase consists of two stages: a) the review of the nature of science literature with the consequent selection of an initial set of 40 items from it and b) the selection and analysis of news on the socially acute question "the COVID-19 vaccine/vaccination". The result was the choice of 11 of the 40 items found in more than five news items (25%) for the construction of the tool.

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29 Scientific Modelling of Socially Acute Questions to Promote Citizenship Action With Preservice Early Childhood Teachers

Daniel Cebrián-Robles, Enrique España-Ramos, Isabel María Cruz-Lorite, Paloma España-Naveira, Francisco José González-García, Aurelio Cabello-Garrido

Malaga University, Malaga, Spain

Abstract

This paper studies the impact of modelling practice through multiple models. It was carried out in a training programme of collective activism based on scientific practices with preservice early childhood teachers at Malaga University (Spain) during 2021/22. The programme has 4 phases: 1) inquiry, 2) action planning, 3) action and 4) evaluation and reflection. Eleven activist projects were carried out on controversial local issues, selected by 11 teams of 4 or 5 students. The students' answers to two open-ended questions on the assessment of the modelling activity for

the development of their activist project are analysed using a system of categories created inductively. According to most students, modelling has had a positive effect on the realisation of their activist projects, not only helping them acquire knowledge but also enabling them to become aware of their views and develop competences to carry out the project. The most difficult part was to identify and/or relate the multiple problem factors in the model and to delimit the project to be represented. However, the quality of the work improved compared to previous years when modelling was not considered.

314 A Time Capsule to Explore a Socially Acute Question. What Futures Images Do High School Students Have of the Digitization of Society and Agriculture?

Nicolas Hervé[1,2], Nathalie Panissal[1,2]

[1]Ecole Nationale Supérieure de Formation de l'Enseignement Agricole, Toulouse, France. [2]Université de Toulouse, Toulouse, France

Abstract

Our paper focuses on the understanding of the futures images that high school students (15 years old) develop about a socially acute question, the digitalization of society and agriculture. To do so, we had 64 students build a time capsule made up of 18 collective filmed testimonies on how they imagine the future of 2040 by addressing different themes related to digitalization. Our results show the ambivalent character of the images formed, as they underline an interest in digital technology for certain sectors of activity (notably those of human health) without adhering to the idea of scientific and technological progress. Environmental issues are also a very present background in the expressed futures. Few images show important societal transitions, as well as the possibility that the problems raised may lead to collective and political empowerment. Our results therefore confirm the importance of addressing the future dimension of a SAQ in the school environment, so that students can emancipate themselves from the dominant anxiety-provoking discourse and develop the means to act for other possible worlds.

481 Wild Citizens: Enabling Children to Become Active Environmental Citizens

Andri Christodoulou, Marcus Grace, Jennifer Byrne, Carys Hughes, Charis Voutsina

University of Southampton, Southampton, United Kingdom

Abstract

In recent times, calls to tackle the climate and nature crisis and live more sustainably are becoming more and more prominent and urgent. Such calls require environmental citizens; that is, citizens who are able to take action at local, national and transnational levels and to assume environmental agency through pro-environmental behaviours, attitudes and values. Placing emphasis on action within learning environments is essential given the current global environmental challenges, and therefore action competences (Sass et al., 2020) need to be addressed and fostered early in young people's education. To enable children to become

active environmental citizens we collaborated with five primary schools in the south-east of England in co-designing and co-delivering a school-based, outdoor 'Wild Citizens' programme focusing on biodiversity enhancement. The children explored their school grounds, discussed, decided, and implemented interventions to enhance its biodiversity, and finally, communicated their findings within their local community and advocated for the importance of their actions. Semi-structured group interviews were used to explore children's' environmental citizenship and action competences. The main themes emerging from our data included (a) environmental awareness and knowledge, (b) environmental responsibility and (c) confidence in own influencing possibilities, with children being able to articulate the importance of environmental protection, and discuss their role within that process. This work provides empirical grounding towards the operationalisation of environmental citizenship at the primary school level.

Parallel Session - 3.5 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

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27 Contextualization, Inquiry, and STEM. Teaching Approaches in Science Teacher Education

Chair

Teresa Lupión-Cobos

Discussant

Leticia García-Romano

Abstract

Teacher training becomes essential for the generation of environments helping to learn, structured with approaches and methodologies that meet the demands of 21st-century education, allowing the evolution in teaching and focusing on constructivist contexts that promote the student's autonomy (European Commission, 2015). How to approach its treatment from the training of science teachers so that their future students are able to mobilize their knowledge and use it in different situations? This Symposium explores the main approaches in science teacher preparation to promote them. Contextualization. The use of teaching approaches focused on daily life problems as useful learning scenarios is widely accepted in literature and its involvement in teacher training (Lupión-Cobos et al., 2017). First communication (UQ) presents an overview of how Indigenous knowledge, culture and histories are incorporated into teacher preparation and PK-12 curriculum, and especially how to contextualize the content. This approach to teaching and learning strengthens community relations and broadens teachers' and students' thinking about Indigenous peoples while enhancing teachers' pedagogies and meeting curriculum standards. Inquiry and Stem Education. The advent of the Framework for K-12 Science Education suggests that the instruction of science education make a radical change focusing on scientific inquiry to learning

about science and integrating dimensions associated with disciplinary core ideas, crosscutting concepts, and science and engineering practices (Jiménez-Liso et al., 2019) that allow students to acquire an adequate understanding of science, technology, engineering, and mathematics (STEM), applicable in real everyday situations to active integration as scientifically and technologically literate citizens. Its use demanding initiatives involving school practices and teachers' professional development efforts (El Nagdi et al., 2018) related to aspects such as the level of integration, the role of disciplinary content knowledge or the development of key competencies. The IBSE, as the central axis of pre-service science teacher (PST) training, is used through the second communication (UPLA+UMA) trying to seek answers about how pre-service science teachers (PST) at three state universities in Chile perceive, before and after being part of an IBSE training program and analysis the resistance to incorporating educational innovations, often based on fear and practical unfamiliarity of methodologies other than the traditional one (Sjøberg, 2019). On the other hand, the lack of resources using science education research promoting scientific inquiry is studied by the third communication (UBU) through a pilot study with elementary school PST. The results reveal adequate levels of usability, which supports the relevance of a 3D inquiry app for smartphones and tablets, which supports the relevance of such a resource. The fourth communication (UV+UMU) explores the vision that future early childhood teachers have about the use of STEM in this educational stage, promoting mathematical, scientific, technological and engineering competence through exploration, manipulation, and experimentation processes playing, to stimulate the innate curiosity of students and help them understand their reality within the reach of their perception and their own skills.

117 Australian Aboriginal Perspectives in Science Education: Co-constructing Learning

Danielle Armour, Jodie Miller, Patricia Morrell

The University of Queensland, Brisbane, QLD, Australia

Abstract

Only recently, Australian teacher standards and curriculum have centred the importance of embedding Australian Indigenous perspectives in the classroom. In this paper we present an overview of how Indigenous knowledges, culture and histories are being incorporated into both teacher preparation and PK-12 curriculum. While many non-Indigenous teachers would like to embed Indigenous knowledges in their instruction, they are not too certain where to start and especially how to contextualize the content. We propose the notion of co-constructing learning with Australian Aboriginal people to foreground knowledges and culture in the primary science classroom as a way to help embed Indigenous perspectives in teaching and learning Science in a contextualized manner while strengthening teachers' pedagogies and including cultural heritage in instruction.

137 IBSE Perceptions of Pre-Service Science Teachers at Three State Universities in Chile

Sylvia Moraga-Toledo[1], Teresa Lupión-Cobos[2], Cristina García-Ruiz[2]

[1]Universidad de Playa Ancha, Valparaíso, Chile. [2]Universidad de Málaga, Málaga, Spain

Abstract

Teacher training becomes essential for the generation of environments helping to learn, structured with approaches and methodologies that meet the demands of 21st-century education, allowing the evolution in teaching and focusing on constructivist contexts that promote the student's autonomy. Under this perspective, the science pre-service teacher training stands crucial to begin to generate changes from the depths of science teaching. For this reason, this research focuses on pre-service science teacher (PST) training as its central axis, seeking to answer the following question: How do pre-service science teachers from three state universities in Chile perceive inquiry-based science education as an educational approach for the development of scientific competencies in their students? To this end, we have applied a questionnaire adapted from the European PRIMAS project. The results obtained from the inferential analysis show that despite the significant differences manifested by future teachers, there is a resistance to incorporating educational innovations, often based on fear and practical unfamiliarity of methodologies other than the traditional one, being this is a comfort zone that keeps PST doing classes in this modality.

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281 Elementary School Pre-Service Teachers' Usability Evaluation of an App for Inquiry Teaching

Radu Bogdan Toma, Iraya Yánez, Jesús Ángel Meneses Villagrá

University of Burgos, Burgos, Spain

Abstract

Although science education research promotes scientific inquiry teaching, teachers do not use it regularly due to a lack of resources. This proposal describes the development of a 3D inquiry app for smartphones, tablets, and PC. A pilot study with elementary school pre-service teachers reveals adequate levels of usability, which supports the use of such a resource.

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128 Approach to Spanish Pre-Service Early Childhood Teachers' Views on STEM

José Cantó[1], Carlos de Pro Chereguini[2], Antonio de Pro Bueno[2], Jordi Solbes[1]

[1]Universitat de València, València, Spain. [2]Universidad de Murcia, Murcia, Spain

Abstract

Relevant studies carried out in recent years indicate that some characteristics of the early childhood education stage, such as exploration, manipulation, experimentation, coincide with those of STEM education. In fact, the Spanish curriculum for this stage talks about promoting mathematical, scientific, technological and engineering competence, through playing, exploring and carrying out simple experiments, to stimulate their innate curiosity and help them understand their reality based on what that is within the reach of their perception and their own skills. In this work we intend to explore the vision that future early childhood teachers have about the use of STEM in this educational stage. To do this, 41 pre-service early childhood teachers' students at the last year of the degree completed in an open-ended questionnaire about STEM, focused in three aspects: 1) How they visualize the relationships between the different parts of STEM; 2) What is the importance and useful of developing STEM in early childhood education; 3) Examples of STEM activities proposed. The results show that, despite the majority considering that STEM relationships are adequate and useful for early childhood education, they find enormous difficulties when it comes to being able to transpose practical examples didactically into their future teaching practice. Therefore, it is important its implementation in the initial training so that they can later take it to the classroom.

Parallel Session - 3.6 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

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22 Children's Experiences and Engagement with Science

Chair

Katia Bill Nielsen

Discussant

Jrene Rahm

Abstract

Research focusing on children has over time undergone large changes, especially in the way children are perceived and thus how their perspectives are taken into account in research. From viewing children as a vulnerable group needing care, to viewing children as a group having important, valuable perspectives and meanings about their own lives as well as relevant knowledge (Clark, 2001). For science education research, this shift has involved a change in approaching what children know and how they learn (National Research Council, 2007), as well as raised attention to the ways children engage with the world around them (Trundle, 2015). Several researchers are now highlighting children as competent inquirers (Keifert & Stevens, 2019; Vartiainen & Kumpulainen, 2020), however it has also been shown that science is not always taught in ways or within settings that provide opportunities for children to engage

actively with science and develop positive experiences (Siry, 2013; Trundle, 2015). In this symposium, we present four different contributions which each improve our understanding of children's relation to and engagement with science. The aim is to investigate children's engagement with science in different contexts. We explore how different structures, pedagogies and settings support children's engagement with and participation in science, as well as how different people around them such as teachers, peers, and family interplay with this process. The contributions focus on children's experiences, agency, emotions as well as the various resources that they draw on when engaging with and making sense of science. The four presentations draw on qualitative data from different national contexts; USA, Israel, Denmark, and Luxembourg. They represent different age groups, and contexts, which spans from formal education to learning in activities outside school, at home and when playing with friends. The breath of the contextual cases will provide the opportunity to contrast the analytical findings. The first paper focus on a kindergarten class children and the ways in which their participation and engagement evolves in open-ended pedagogical structures, with a view towards understanding children's emotional, embodied engagement as they engage in interaction around science phenomena. The analysis is grounded within critical cultural studies with a focus on the dialectic between agency and structure. The second paper follow young children through the first years of primary school and explore how they engage with science both within the primary school classroom and during informal playful situations such as during breaks. The paper draws on the concepts of worlds and world travelling to unpack the challenges that some children experience in relating to school science. The third paper examines middle school students' engagement in an out-of-school science project, and how this allowed them to engage in playful self-discovery and what the authors term identity play. A theoretical construct drawing on literature on self-making and the concept of wayfaring. By introducing identity play the authors highlight the multifaceted and non-linear aspects of self-making. The fourth paper explore children's engagement with science in the informal learning environment of their families. By comparing two cases, the paper unpacks the initiation of science activities and the family interactions during these activities. The analysis focus on the provision and use of various forms of resources and how this prompted or hindered the children's epistemic agency. Based on the four contributions, the symposium will open a discussion of future avenues for research in children's relation to and experiences with science. Just as we invite for a discussion of the implications the findings have for how we might support this both within and out of school.

763 Exploring Structures that Mediate Children's Embodied, Emotional, Agentic Science Engagement

Christina Siry, Sara Wilmes

The University of Luxembourg, Esch-Belval, Luxembourg

Abstract

This proposed contribution to the symposium explores structures that support elementary students' agentic participation in science investigations, with a view towards understanding

children's emotional, embodied engagement as they engage in interaction around science phenomena. The research was conducted with a class of 4- to 6-year-olds as they participated in the five-week unit exploring living things in a Kindergarten classroom. Situated in a multilingual national context, the research examines the interactions of these plurilingual children as they discover, observe, and interact with worms, with materials, and with each other. Multimodal interaction analysis (authors) grounded in the sociology of emotions (Collins, 2002) reveals the nuances of how open-ended pedagogical structures create a space for children to engage with science in a range of ways that generate positive emotions, including joy, pride and wonder. These are found in anticipation of the investigation, in the embodied interactions between materials, children and worms, and in dialogue and documentation around children's discoveries. We posit that these emotions emerge in the relationship between children's unique individual and collective embodied science inquiries, documentations, and interactions with others and materials. Findings demonstrate the role that material resources play in structuring students' engagement and highlight the unique ways in which children engage with science, with materials, and with each other. The analysis reveals that open ended pedagogical structures mediate the emergence of positive emotions, and a central component to these structures is time and space – space and time for movement and interaction of children, materials, and exchanging ideas.

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132 The Worlds of Young Children and their Encounter with Science

Katia Bill Nielsen, Henriette Holmegaard

University of Copenhagen, Copenhagen, Denmark

Abstract

In this paper, we explore the perspectives of young children and how they make sense of their experiences with science, both within the primary science classroom as well as during informal, playful situations. The paper draws on empirical material from a longitudinal research project following children in primary school through qualitative interviews and ethnographic fieldwork. By exploring the children's experiences through the theoretical lens of 'worlds' and 'world travelling', we unpack how the children make sense of diverse experiences with science in different contexts. The analysis shows a discrepancy between the worlds of young children and that of primary school science, and we argue that this cause unequal opportunities for children to participate and be recognized as competent in the primary school science classroom. By taking the perspective of the young children, we add to the understanding of how children connect and make sense of diverse experiences with science, and we explore some of the challenges of primary school science and the provision of equal opportunities for participation in science.

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135 Children's Self-Making through Identity Play: Nonlinear Aspects of Identity Development

Heidi Carlone[1], Alison Mercier[2]

[1]Vanderbilt University, Nashville, TN, USA. [2]University of Wyoming, Laramie, WY, USA

Abstract

Identity development has been described as a process of identity regulation—structural arrangements that act to govern and shape people's identities—and identity work, which includes people's responses to identity regulation. While identity regulation emphasizes structural aspects of self-making, and identity work emphasizes a structure/agency dialectic, we introduce identity play, which emphasizes the agentic, nonlinear aspects of self-making. This is a grounded study of youths' identity play as they engaged in out-of-school, integrated STEM programs focused on environmental problem solving across three years. We outline features of identity play, illustrate what it looks like, and resources youth leveraged to do it with Mirabel's case. Mirabel's identity play emphasizes processes of self-discovery versus end points.

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133 Resource Use and Epistemic Agency in Family Science Engagement

Neta Shaby[1], Dana Vedder-Weiss[2]

[1]University of Southampton, Southampton, United Kingdom. [2]Ben Gurion University of the Negev, Beer Sheva, Israel

Abstract

In this multiple case study, we employed linguistic ethnographic microanalysis to explore epistemic agency in family science engagement. Epistemic agency is an essential dimension of scientific practices that positions the learners as constructors of knowledge, through their involvement in questioning, challenging, contrasting ideas and more. Research demonstrates how informal learning environments promote children's epistemic agency, by providing a broad array of resources and supporting various ways of using them. Families use various resources (material, social, conceptual, procedural, and epistemic) while engaging with science at home, however, different families use resources in different ways. In this study, we explored how parents shaped the use of resources during family science engagement and how this promoted or hindered children's epistemic agency. We compared between two families, examining video recordings the families collected, and focusing on the same activity, "Scientific ice-cream" experiment, in the two families. Our findings demonstrate that although both families had the same material and procedural resources, and presumably the same conceptual resources, the social resource (the mothers in this case) had an important role in constructing the interaction. This affected who had access to the resources and the way the children navigated the inquiry and constructed or challenged problem solving and decision making.

Parallel Session - 3.7 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

Subject Matter Learning in Physics: Contributions to IHPER

Chair

Mehmet Fatih Tasar

Discussant

Marisa Michelini

Abstract

The International Handbook of Physics Education Research (IHPER) is a collective work of 170 physics education researchers from around the globe. IHPER is organized into 12 sections in 3 volumes. The first section focuses on "Subject Matter Learning" in physics. The chapters in the section cover the following topics: sound and waves; fluids in equilibrium and hydrodynamics; thermal physics; energy; electricity and magnetism; optics; Galilean and relativistic kinematics; quantum physics; radioactivity, radiation, and particle physics. In this symposium a general overview of IHPER will be given and participants will outline their reviews and analyses of the literature in electricity and magnetism; optics; Galilean and relativistic kinematics; and conceptual change models in physics (from classical to quantum physics looking into personal vs physics epistemologies in the theories.) Professor Marisa Michelini is the discussant for this symposium.

157 Research on Student Learning of Foundational Concepts in Galilean and Relativistic Kinematics: The Role of Operational Definitions

Stamatis Vokos[1], Andrew Boudreaux[2], Rachel Scherr[3]

[1]California Polytechnic State University, San Luis Obispo, CA, USA. [2]Western Washington University, Bellingham, WA, USA. [3]University of Washington, Bothell, WA, USA

Abstract

This talk summarizes a chapter on relativity that was submitted by the authors to the International Handbook on Physics Education Research. In addition to outlining the status of research in this field, the talk will also reflect on the implications of this work and connections with current research on cognitive aspects of learning physics. In particular, we illustrate the foundational role that operational definitions underlying physical measurements play in learning and teaching. This focus on measurement seems to be a generalizably useful feature that allows a learner to differentiate among related concepts. This process of learning what a concept is by contrasting its measurement with related measurements of what it is not has been shown to be useful in many disparate contexts and must be a general feature of human

cognition. This work also has implications for project-based learning, according to which students learn what is needed to complete a task or a piece of a complex project, without necessarily building hierarchical connections with all prerequisite concepts.

239 Literature Review on Teaching/Learning Optics

Claudia Haagen-Schützenhöfer[1], Thomas Schubatzky[2], Markus Obcovsky[1]

[1]University of Graz, Graz, Austria. [2]University of Innsbruck, Innsbruck, Austria

Abstract

Research on content and context-dependent teaching and learning (content research) in science is a phenomenon of the last century. International interest in this field can be seen from the 1970s onward. The output of content research covers a variety of content areas of physics and target groups of learners. However, optics is one content area of classical physics that has not been at the center of focus of content research. Nevertheless, research results of different research strands have accumulated over the years and provide relevant insights and evidence on challenges, pitfalls, and supporting elements for teaching/learning optics. This presentation, which is based on a contribution in the new International Handbook of Research on Physics Education, aims to portray the current status of empirical research in the field of teaching/learning optics at the secondary level and to give an overview of research interests and research-related approaches, research findings and future perspectives for content research on teaching/learning optics.

240 Students' Understandings of Electricity and Magnetism

Paul van Kampen[1], Mieke De Cock[2]

[1]Dublin City University, Dublin, Ireland. [2]KU Leuven, Leuven, Belgium

Abstract

In this talk we will highlight some of the physics education literature on students' ideas about electricity and magnetism. The research reviewed spans all age groups and includes work carried out within a wide variety of frameworks. We start with students' ideas about electric charge, attraction and repulsion, charging, polarization, and magnetic interactions primarily from a qualitative viewpoint. We then describe research related to students adopting a more quantitative approach: electrostatic and magnetostatic force and field; the superposition principle; electric potential, electric potential energy, and capacitance. A discussion of research on students' understandings of representations and commonly used diagnostic tests serves as a bridge to more advanced topics that often also require more advanced mathematical techniques such as integration and vector calculus: Gauss' Law, Ampère's Law, and Faraday's Law. Throughout the talk we highlight where we have found gaps in the literature.

295 An Overview of the International Handbook of Physics Education Research (IHPER)

Mehmet Fatih Tasar

Georgia State University, Atlanta, GA, USA. Gazi University, Ankara, Turkey

Abstract

The International Handbook of Physics Education Research (IHPER) is organized into 3 volumes with 12 sections. Each section has been edited by prominent scholars in the field of Physics Education Research (PER). It has now, in its finished form, become an enormous resource that lays out most significant research works, if not all, with analysis and synthesis of the literature. We thank all involved colleagues for their dedication, perseverance, rigor, hard work, and patience until the very last moment, despite the COVID-19 pandemic that broke out right in the middle of our work on IHPER. Since 2019 Professor Paula Heron and I have agreed to tackle this idea as a project. We met during the GIREP meeting in Budapest and improved the concept together. While at the conference we made initial contact with many prominent colleagues and sought their feedback. They were all positive and encouraging. Secondly, we searched for a publisher. Their main concern was marketing. We are grateful that AIP Publishing has approached this project in a constructive and helpful way. And that attitude made this grand work possible. The first conceptualization of IHPER has a longer history for me. During the best part of the last decade, I have been thinking about creating such a handbook by taking previously published handbooks in science education as a model. I imagined that a new researcher in the field would be able to see a map of the terrain in such a handbook. The bold and fine lines of research and the main contributors. I thought they would know what kind of gaps existed in the literature and where they would be making contributions. The roots, body, and the branches of PER could only be portrayed as a result of a great effort of this scale. We made it! Congratulations!

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342 Theoretical Inquiry for Learning Quantum Mechanics: Operationalizing Thought Experiments

Giacomo Zuccarini, Marisa Michelini, Lorenzo Santi

University of Udine, Udine, Italy

Abstract

For promoting the acceptance of the quantum model as a plausible description of physical reality, we designed a course for secondary school students around a modelling process including epistemic practices of theoretical nature, which are at the core of the construction of quantum mechanics as a knowledge domain. To this purpose, we developed a framework describing historically significant practices used by physicists to build new scientific knowledge by means of theoretical reasoning, and converted them into modelling activities. Here we focus on the strategies used to engage students in generating and/or running thought experiments,

as an innovative form of inquiry. Data on student ideas and learning outcomes are reported for illustrating this process and to show the feasibility of such activities at school.

Parallel Session - 3.8 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

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46 Making Spaces for Stories in And of Feminist Science Education Research

Chair

Katerina Pia Günter

Discussants

Jennifer Adams, Sara Tolbert

Abstract

How and where can feminist perspectives support renewed investigations about sociocultural issues and alternative epistemologies in science education? The search for possible answers to this question is the starting point of this symposium. Holding conversations framed by feminist scholarship, we focus on narratives of and about people engaged in science, science education, and science education research. Inspired by Clare Hemmings (2011), we bring attention to students', educators', and researchers' stories, collectively reflecting on how, what, and why stories and the way they are told matters. Our contributions are rooted in science identity research, yet reach beyond unidimensional explorations of practices in science education. Together, they tell stories in and of feminist science education research, bringing into focus the practices' participants and mapping out how norms and imaginaries of science and science education inform and influence people's identity work in historically, culturally, and socially constructed spaces. The first two abstracts tell stories about explorations of selves by science educators and science education researchers. Author1 and Author2 share their experiences when using collective mapping in a course on science teachers' professional development. They turn the reflective mirror upon themselves to explore territorialities, oppressions, and hierarchies in science educational spaces. Author3 takes a feminist approach to creative research methods, engaging in the creation of a collage as means to (re)think processes of in/exclusion in science. Through an autoethnographic account, she explores the complexities of becoming a physicist. Both contributions discuss critical and creative approaches to teaching and researching in science education, challenging traditional epistemologies and hegemonic discourses of science educations as disembodied practices. Two contributions employ materialities and embodiment to research sites and tell stories about how teaching and learning science can be felt through the body in geoscience contexts. From an ecofeminist perspective, Author4 and Author5 tell the story of a geoscience student in a large Canadian city who experiences a 'work hard, play hard' culture, one that she feels through *drinking*, *forcing*, *blocking*, and *carrying*. Author6 and Author7 take a material feminist perspective to explore

how a hammer, a central tool in geoscience practice and education, becomes an artifact that provokes bodily sensation and acts as a tool in the process of embodying geoscience practices. The contributors, most of whom are early career researchers, come from and are located in different countries around the globe. We speak different languages, are enculturated within different academic traditions, have different academic backgrounds, hold different experiences as science educators, and engage in different traditions within cultural heritage of feminist scholarship. These multiple differences are brought together in the symposium to enrich encounters with each other, ourselves, the people with whom we conduct our research, and the objects of our research. As claimed by Gloria Anzaldúa (1987), we are in borderlands of geographical and disciplinary territories. As scholars committed to different ways of academic activism, we find ourselves in-between often conflicting traditions, practices, and interests. Nonetheless, following Donna Haraway (2016), we explicitly want to stay with these troubles. Therefore, we approach science education research as "a site of contest, a theme and an object of democratic debate" (Butler, 2005, p. 6) in this symposium and invite researchers to have hard conversations about ourselves and about the stories that we are living and (re)telling in our practices.

430 From Collective Mapping to Body Mapping: Contributions of Feminist Geographies to Science Education From the South

Paulina Bravo[1], Valeria León[2]

[1]Universidad Católica del Maule, Talca, Chile. [2]Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile

Abstract

We are two teacher educators proposing a methodological point where feminist geographies (Valeria´s area) and science education (Paulina's area) meet. Based on the strategy of collective mapping in the context of a continuous professional development (CPD) course with science teachers and the powerful idea of the body as the first territory, we turn the 'reflective mirror' to look at ourselves as teacher educators questioning our practice. We started by mapping our body, recognising in us oppressions, hierarchies, and intersections to then invite others to do the same in a safe space. Contributions to both feminist geographies and science education and teacher education are discussed.

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438 The Role of Affect and Reflexivity in Science Education Research: Investigating Selves

Carolina de Barros Vidor

Uppsala University, Uppsala, Sweden

Abstract

Drawing on feminist scholarship and creative research methods, in this paper I present a critical approach to affect and the enactment of reflexivity in science education research, understanding it both as a mode of doing research as well as being a researcher. I created a collage of images representing issues of in/exclusion in science and composed an autoethnographic account about the ways that this creative process has affected me, the researcher. Based on that, I discuss the process of becoming a physicist, which implies on embodied modes of existence based on violent epistemological regulations within physics. Finally, I discuss the relevance of findings for researchers investigating exclusionary processes in science and science education.

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456 "It's a Work Hard, Play Hard Culture": Sensing Geoscience Education

Sarah El Halwany, Maryam Taheri, Jennifer D. Adams

University of Calgary, Calgary, Canada

Abstract

This paper is situated within the vast literature that examines issues of underrepresentation faced by racially and gender diverse students in science education. It explores how contexts of geoscience education contribute to a 'linked networked of dualisms' that reinforce binary distinctions between feminine/masculine, nature/culture and emotion/reason. We examine how those demarcations get enacted affectively at the level of the 'skin' as 'atmospheric practices' and are not simply conceptually/discursively rehearsed. The linkage between those dualisms became apparent following interviews with 'Jessica' a graduate student in the geoscience department retelling her experiences with sexual harassment and micro-aggressions in a "work hard, play hard culture".

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579 A Story of a Hammer - Learning With Materialities in Earth Science Fieldwork

Rie Malm[1], Katerina Pia Günter[2,3]

[1]University of Copenhagen, Copenhagen, Denmark. [2]Uppsala University, Uppsala, Sweden. [3]San Francisco State University, San Francisco, USA

Abstract

We explore the story of a hammer, its interaction with students and how its materiality influences students' learning as becoming while being in the field. Working with and using tools and instruments is often taken for granted in fieldwork. It can be understand to be a bodily act, leading to embodied knowledge, which is hard to convey in oral or even visual instruction. While we see students use them in 'wrong' or 'right' ways, we rarely problematise how their use actually influences their users. This paper aims to add a dimension to and deepen our understanding of the phenomenon from a feminist perspective, focusing on the tools we use

in a fieldwork setting. With this, we aim to add a specific critique of a scientific tradition and culture that continues to separate minds from bodies and materialities from knowledges and learnings, resulting in subtle exclusions of certain people. The feminist lens helps us question a rather unchallenged practice such as fieldwork, and by exploring materialities, uses and impact of the hammer, we show further entanglements of learning and identity processes in the field.

Parallel Session - 3.9 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

Analysing and Interpreting Students-Generated Drawings: Methodogical and Practical Perspectives

Chair

Italo Testa

Discussant

Anastasios Zoupidis

Abstract

Drawings have been long used to analyze students' understanding of scientific concepts. Research has also shown that to involve students in drawing can be a successful strategy to enhance learning, stimulate cognitive processes and improve spatial thinking. Given such variety of research aims, several methods of analysis have also been adopted, ranging from simple indexing schemes or rubrics to more complex frameworks based on the semiotic interpretation of the pictorial signs. However, most of the adopted methods do not allow the researchers to directly identify which specific mental model underlies the generated drawing. Moreover, it is not clear what factors influence the choices made by the students in their drawings and whether such choices are related to their mental models of the represented phenomenon. The aim of this symposium is to bring together researchers to answer to the following questions: *what methods can be used to effectively analyse students' drawings? What are the conceptions underlying students' drawings? How are student-generated drawings influenced by teaching practice and materials?* To answer these questions, the papers in this symposium will adopt a common framework in which the act of drawing is conceptualized as a cognitive process that involves two steps: the activation of a subjective mental representation of a concept or phenomenon, and then the externalization of such representation employing nonverbal and referential visual signs, which include lines, segments, circle, arrows, mathematical symbols. According to prior work, drawings will hence be considered to be a semiotic system constituted by meaning-making signs organized by the learner with the aim of explaining and presenting a concept or phenomenon. The representational modality chosen by the learner will be the result of pictorial conventions adopted in a cultural context. The student-generated representation will be also influenced by expectations, artistic aims, or

simple practical reasons. Starting from this common framework, each contribution will address a specific aspect of the overarching research questions. The first paper will focus on Multiple Correspondence Analysis, a well-known multivariate method, to analyze students' drawings about seasons. In particular, the paper will show how this method can be effectively used to analyze a large number of drawings by extracting few latent dimensions, which summarize the main features of original data. The second paper, taking sea tides are example, will focus on how to identify students' mental models from their drawing. The third paper will discuss the main features of students' drawings about greenhouse effect. Finally, the fourth paper will discuss the graphical features of students' drawings about gravity in terms of the p-prims cognitive perspective. While the results of the four papers are interesting from the methodological viewpoint, we expect that the involved researchers will bring to the table also meaningful implications from the teaching practice viewpoint. First, the evidence collected in the four studies will be useful to understand whether textbook illustrations at primary, middle and high school help the students generate drawings from which it is possible to infer the causal mechanisms of the represented phenomenon (seasons, tides, greenhouse effect, gravity). Second, the four studies will suggest which graphical elements in the student-generated drawings may indicate possible misconceptions about the represented phenomenon. Finally, the transversal theme of how to improve students' modeling skills by involving them into drawing activities will be briefly addressed in the final discussion of the symposium.

174 Using Multiple Correspondence Analysis to Investigate Students' Drawings of Seasons

Italo Testa[1], Silvia Galano[1], Raffaele De Luca Picione[2]

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Abstract

We analyzed students' drawings about seasonal changes using Multiple Correspondence Analysis (MCA). While this technique is widely used in health and social research, it is rarely used in science education. Through the use of MCA, students-generated drawings can be analyzed in terms of latent dimensions that group common features of the pictorial representations. We collected 495 high school student-generated drawings about the cause of seasons. From the MCA, we extracted three latent dimensions underlying students' drawings that explain the 78.58%, 9.89% and 6.14% of the total variance in the data, respectively: 1) observer' adopted viewpoint, 2) personally experienced effects, 3) temporal sequence of the seasons. Our study suggests that MCA can be productively used to analyze large numbers of students-generated drawings of natural phenomena and to identify specific features of textbook images that may cause difficulties in understanding the targeted topic.

334 Is It a Ray or Is It an Energy Flux? Analysing Student Drawings of the Greenhouse Effect

Pasquale Onorato[1], Camilla Fiorello[1], Massimiliano Malgieri[2], Marco Di Mauro[1], Stefano Toffaletti[1], Tommaso Rosi[1], Stefano Oss[1]

[1]Department of Physics, University of Trento, Trento, Italy. [2]Department of Physics, University of Pavia, Pavia, Italy

Abstract

We report preliminary results on a critical analysis of student drawings, accompanied by explanations, representing the basic physical mechanism of the greenhouse effect. We consider drawings produced by students at different level of instruction before and after a teaching learning sequence of our design. We discuss the most fruitful methods to analyze student drawings, and we also look for correlations with pictures and diagrams found in school textbooks.. Finally, we also consider the evolution of drawings before and after the exposure to the TLS are compared.

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354 University Students' Understanding of Tides

Mieke De Cock[1], Danilo Catena[2], Hans Van Winckel[1]

[1]KU Leuven, Leuven, Belgium. [2]University of Udine, Udine, Italy

Abstract

In this study, we analyzed the descriptive and explanatory knowledge of the phenomenon of tides in a sample of students in a Master's Degree in Astronomy & Astrophysics. We administered a questionnaire consisting of open ended questions. Based on a categorization scheme from literature, we analyzed student answers which in most cases contain drawings to support the explanation. We conclude that most students realize that the gravitation between Earth and Moon plays an important role but many students cannot explain the phenomenon correctly. Although the distribution over the categories is different, our students show similar difficulties as those described in earlier research.

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473 Drawings and Knowledge Fragments About Free Fall

Nilüfer Didiş Körhasan

Zonguldak Bülent Ecevit University, Zonguldak, Turkey

Abstract

Phenomenological primitives (p-prims) are abstract, general, oversimplified, context dependent, and implicit knowledge elements operating preconscious level and could form complex cognitive structures. With the knowledge of drawings are important tools for both construction and investigation of scientific knowledge, this study aimed to investigate the

implicit knowledge fragments associated with reasoning and allowing causal explanations in different physical cases and the contexts with the help of drawings. With the participation of 274 pre-service primary teachers, six p-prims for free fall in two cases and three contexts were examined. While conclusions of this research show knowledge fragments underlying their drawings, they also present and discuss an analysis effectively used for drawings.

Parallel Session - 3.10 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

65 Diversity in Science towards Social Inclusion – Non-Formal Education Follows Inclusion

Chair

Silvija Markic

Discussant

Rachel Mamlok-Naaman

Abstract

One of the main goals of science lessons is gaining content knowledge. However, science knowledge is unevenly distributed and so is the access to this important section of the job market. A major challenge in science education is to support every student in a way that he or she can learn science in the best possible way. Especially those groups of students who differ from the 'norm' are disadvantaged in science. This is true for students with a lower socio-economic status, those who speak other languages at home than the language of instruction, or who belong to ethnic minorities. Unexpectedly, also the group of gifted students tends to be disadvantaged and underrepresented in science. In addition to formal education in schools, science content and skills are also required and fostered in non-formal education. Non-formal learning takes place outside of school in an open and unrestricted setting but is structured and organized as well as oriented towards the educational curriculum and its topics. Studies investigating the effectiveness of different non-formal educational offers on scientific topics have shown that those have positive effects on students. Even a single visit has a short-term significant positive impact on self-concept, intrinsic motivation for science, and interest in the subject. Thus, the participants of the symposium have come together to develop and implement innovative methods and practices for inclusive non-formal education offers. We want to promote inclusive science education and foster the education of different groups of disadvantaged students in our society, including supporting also different educators of leaders of informal and non-formal educational institutions. We focus on differences in students` linguistic competences, their socio-economic backgrounds, in their cultural background, their

giftedness which is strongly connected to interest and motivation and students` ethnic backgrounds (especially ethnic minorities).

Following presentation will be a part of the symposium:

1. Development and implementation of innovative concepts for language-sensitive student laboratory
2. Exploring and intervening in the science capital of "low" socio-economic status pupils: an Irish middle school study
3. Constructing science interventions around cultural plurality – a case study
4. Inquiry based chemistry activities in the non-formal educational setting for gifted students

The symposium will finally discuss the connection of the presented studies and sum up a pedagogical approach for inclusive non-formal education. In the symposium, we want to show that the active, cooperative, and inquiry-based participation of all students in out-of-school education is possible by connecting different approaches presented in the symposium. Thus, we want to discuss a shared set of pedagogic approaches that benefit all learners and thus is truly inclusive. It considers inclusive pedagogy as a coherent approach. Our goal is to share knowledge and skills about our pedagogic approaches for implementing inclusive education in out-of-school offers.

989 Development and Implementation of Innovative Concepts for Language-Sensitive Student Laboratories

Silvija Markic[1], Sarah Kieferle[2]

[1]Ludwig Maximilian University of Munich, Munich, Germany. [2]Ludwigsburg University of Education, Ludwigsburg, Germany

Abstract

In the past decades, society in general has become strongly diverse. This change also affects schools. As a result, learning groups cannot be seen as homogeneous and taught in this way. One of the challenges is students' linguistic skills. Dealing with different linguistic competencies should not only be a focus of formal education in schools but supported by non-formal education such as student laboratories. Thus, there is a need for practical examples that are effective for teaching and learning of diverse groups of students and enables them to be an active part of the learning process. Learning settings for student laboratories that enable active participation for all students irrespective of their linguistic competencies are developed and implemented following the model of Participatory Action Research. In a cyclical approach, language-sensitive and language-supportive learning materials are developed, implemented, and evaluated focusing on different chemical contents. Qualitative data are collected during the experimentation phase using a semi-structured observation sheet. In two cycles, we evaluated semi-structured observations of eight learning groups of different grade levels and school types with a total of 163 students. The observations are analyzed using inductive

qualitative content analysis. The results show an optimal composition of approved methods, tools, and activities as successful examples. Furthermore, interdependence between different factors could be identified that have positive relations with active participation of all students.

1007 Inquiry Based Chemistry Activities in the Non-Formal Educational Setting for Gifted Students

Luka Vinko, Miha Slapnicar, Janez Vogrinc, Iztok Devetak

University of Ljubljana, Faculty of Education, Ljubljana, Slovenia

Abstract

The aim of this study is to illustrate the development of learning modules and their adaptations for teaching chemistry in the context of the IBL (Inquiry-based learning) approach in non-formal educational settings and to find out whether the original Project Name modules and the adapted modules have significantly different impacts on students' situational interest in chemistry and on their views about IBL in non-formal educational settings. A total of 136 Grade 8 and 9 students from 11 lower secondary schools across Slovenia participated in this study. 68 students participated in the non-adapted Project Name module application and 68 in the adapted Project Name module application. The results show that the non-adapted module was equally interesting for both gifted and non-gifted students, whereas module adaptations had a positive effect on non-gifted students' interest it was exactly the opposite with the gifted who showed more interest in the non-adapted module. When comparing how students perceive IBL, it was found that the gifted students had a better attitude towards IBL before the module adaptations whereas the non-gifted students showed no difference in their attitude towards IBL, regardless of whether they participated in the lab work before or after the Project Name module adaptation.

1014 Exploring and Intervening in the Science Capital of "Low" Socio-Economic Status Pupils: An Irish Middle School Study

Genco Guralp, Sarah Hayes

University of Limerick, Limerick, Ireland

Abstract

This presentation describes a study designed to develop interventions in the non-formal science education sector to augment the science capital of students from "low" socio-economic backgrounds. Following a Design Based Research methodology, we designed a pilot study that makes use of inquiry-based activities, including "hands on" workshops, group discussions on nature of science, and debate activities on ethics of science. Using a pre- and post- instrument specifically developed for the project, we measure science aspirations and science identity of the pupils. Our preliminary results indicate that interventions in the non-formal sector can produce short term impact by making science "fun" and contributing to a sense of belonging

in a community of learners among the pupils.

1026 Constructing Science Interventions Around Cultural Plurality: A Case Study

Jane Essex, Ingeborg Birnie, Kirsty Ross

University of Strathclyde, Glasgow, United Kingdom

Abstract

This presentation describes a two sets of science outreach activities conducted as part of the Diversity in Science for Social Inclusion Project. The activities had characteristics of both non-formal and informal education and were intentionally designed to be suitable for use in a range of settings other than school. The two sets of activities differed in their cultural context, the degree of open-endedness in the task and the extent to which the people doing, or affected by, the science was a focus. The presentation then considers the characteristics of the evaluation tools used and how these mapped against the intentions of the interventions provided. We also consider the differential responses to the different evaluation tools. Finally, we consider evidence on how the two sets of activities altered participants' understanding of what science is and to whom it is relevant. The findings are considered within the theoretical framework of epistemic justice (Fricker, 2007) and the extent to which short-term interventions can redress systematic epistemic injustice in science is considered.

Parallel Session - 3.11 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

66 The Interplay Between Argumentation and Epistemic Practices in Science Classroom Talk

Chair

Edit Yerushalmi

Discussant

Baruch Schwarz

Abstract

A central goal of science education is to foster students' epistemic cognition, that is, to help students develop a more sophisticated understanding of the pathways in which scientific knowledge is constructed and evaluated. The advent of dialogic pedagogies has brought argumentation and epistemology to the fore of the educational scene in their intricacies. For instance, participation in scientific argumentation may reflect and be shaped by learners'

epistemic beliefs. At the same time, argumentation can lead to a better understanding of the epistemic practices used to construct scientific knowledge. From the beginnings of philosophy in the Hellenic culture, the relationships between argumentation and epistemology were complex: For Sophists, argumentation was practiced to reach social and political goals. For Plato, who fiercely opposed the views of the Sophists, it served as a central tool to reach truths. The present symposium provides a window of the richness of the interplay between argumentation and epistemology in the context of science education. However, studying this interplay necessitates a differentiation between goals pursued, as well as epistemological entities considered in the context of science education. Osborne and Reigh provide a language for describing the different types of dialogue and their disciplinary purposes. They focus on the promotion of epistemic goals through educational dialogues, showing the intertwining between epistemic practices and dialogic moves that support them in the classroom. The classification undertaken has important educational implications as it serves as a roadmap for promoting epistemic goals through argumentation. Bächtold and De Checchi are interested in the promotion of epistemic practices in argumentation on socioscientific issues (SSI's). They examine the relationships between the epistemic practices that high school students deploy in the course of argumentation and their beliefs about these epistemic practices, and about knowledge and opinions in general. Their study shows the complexity of the role of different beliefs in argumentation. The efforts students invest to meet norms of argumentation on SSI's seem to have little correspondence with their beliefs. The analysis that Bächtold and De Checchi provide shows that although argumentation and epistemology are intertwined at the level of beliefs, their relationships are not harmonious in discussions of social studies topics. The perspective taken by Sandoval and Clark brings to the fore the political. They pledge for an integration of science education and engagement with sociopolitical issues, but unlike the other presenters, the epistemic practices serve the political goal. Sandoval and Clark frame this new direction in a high-school chemistry course oriented around sociopolitical questions of climate change and its effects on an urban school community. Their focus on community, and on the historical, social and political factors causing climate change, positions science not as a discipline, but as a tool for engaging in worthwhile actions. This original contribution links epistemic practices with sociopolitical actions. The contrast between Sandoval and Clark's contribution and the research described by Perl, Schwarz, and Yerushalmi is blunt. To some extent, it resonates the contrast between the role of argumentation in the Hellenic times: Perl, Schwarz, and Yerushalmi consider argumentation as a path to know better, i.e., to construct scientific knowledge. The context - the meeting between Out-of-field and In-field physics teachers - provides a propitious ground for mutual learning and elaboration of enriched epistemic practices among physics teachers from different disciplinary backgrounds. Perl, Schwarz, and Yerushalmi exemplify in the most salient way what is common to all presentations, the fact that advancements in epistemic practices in argumentation depend on a meticulous design. Without tremendous efforts of design, talk between students or teachers does not deploy as deliberative argumentation and does not invoke the desired epistemic practices.

1028 Towards a Framework for Clarifying the Nature of Dialogue in Science Learning

Jonathan Osborne, Emily Reigh

Stanford University, Stanford, California, USA

Abstract

Whilst much has been made of the importance of argumentation and academically productive talk, one of the factors inhibiting its use is a lack of a language for describing the different types of dialogue and their disciplinary purposes. In this paper, drawing on the work of Burbules (1993), we offer a conceptual framework for both the types of dialogue that occur in science classrooms—and their disciplinary purposes with a specific focus on inquiry dialogues. Greater clarity about both the types of dialogue and their disciplinary purposes offers two important features to the field. First, it provides a language for discussing the nature and purpose of the dialogue which we argue has been insufficient to date. Second, it offers a means of identifying the epistemic function of the dialogue and how it might be better supported in the classroom. Using our framework, we classify a range of types of questions gathered in our research to illuminate what types and purposes of dialogue predominate and, notably, what is missing.

1035 Students' Argumentation on Socio-Scientific Issues and Their Beliefs About This Epistemic Practice

Manuel Bächtold, Kévin De Checchi

University of Montpellier, Montpellier, France

Abstract

A major educational challenge in science education is for students to acculturate to epistemic practices. To understand how students engage in such practices, research has been conducted on students' beliefs, with an approach focusing on epistemic beliefs (i.e. beliefs on knowledge in general, BK), the other on beliefs about epistemic practices (BEP). In the present study, we cross these two approaches to investigate how high school students engage in the practice of argumentation in a debate on a socioscientific issue (SSI). The aim is to highlight possible coherences between students' epistemic beliefs, their beliefs about the aims of a debate and criteria for achieving those aims, and their practice of argumentation. Since SSIs involve both knowledge and opinions that may be related, we propose to study BK jointly with beliefs about opinions (BKO). The fine-grained qualitative study that was carried out is based on interviews with 12 high school students and their contributions to a debate on an SSI. In the debate, students tend to meet three norms of argumentation on SSIs (justification, others and complexity), what is found to be hardly consistent with their BKO and BEP. Students also tend not to meet three other norms (questioning, uncertainties and open-endedness). In this respect, the consistencies with their BKO and BEP are more frequent, but are expressed in a negative way, in the sense that BKO or BEP imply that certain norms of argumentation about SSIs are not

met.

1042 Interdisciplinary Dialogic Argumentation and Change in Epistemic Practices Among Physics Teachers

David Perl-Nussbaum[1], Baruch Schwarz[2], Edit Yerushalmi[1]

[1]Weizmann Institute of Science, Rehovot, Israel. [2]The Hebrew University, Jerusalem, Israel

Abstract

Many teachers whose academic background and primary teaching experience is in the life sciences are called to teach middle school physics. Based on previous studies, we expected these out-of-field teachers to hold different epistemic cognitions than the teachers from within the field. This study builds on this epistemic diversity and proposes interdisciplinary dialogic argumentation as a means to promote mutual learning and productive epistemic practices among physics teachers from different disciplinary backgrounds. We report on professional development argumentative tasks designed to encourage teachers to express their disciplinary perspectives in the context of inquiry-based physics. We used discourse analysis to examine the type of discourse that evolved between the teachers as well as the epistemic practices they applied during the course of their scientific arguments. A preliminary analysis across three groups of teachers - two homogeneous groups consisting only of in-field or out-of-field teachers and one heterogeneous group - revealed that teachers employed epistemic practices characteristic of their primary discipline. The in-field teachers tended to justify their claims theoretically, while the out-of-field teachers provided more empirical justifications, and their theoretical justifications relied on authority. In the heterogeneous group we witnessed a highly deliberative discourse among the teachers. The composition of this group allowed for a process of negotiation and enhancement of mutual epistemic practices, demonstrating the potential of interdisciplinary dialogic argumentation to develop sophisticated epistemic cognition.

Parallel Session - 3.12 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

56 Future-Oriented Science Education to Regenerate School Systems for the Society of Acceleration and Uncertainty

Chair

Olivia Levrini

Discussants

Richard Duschl, Guia Bianchi

Abstract

Scientific and technological development has been driving fast societal changes, and the educational systems are struggling to keep up with the pace of such transformation. As a result, youth do not find in education the resources needed to construct empowering visions of their future and develop competencies to navigate a complex, fragile and fast-changing society. In the symposium, empirically based studies are presented as outcomes of a European project aimed at developing a future-oriented model for science education to regenerate school systems for the society of acceleration and uncertainty. Three forms of misalignment that emerged between educational systems and society are addressed in the set of papers:

a) the clash between the vertical and hyper-specialist organisation of teaching in the disciplines and the inter-multi-transdisciplinary nature of the new modus operandi of scientific research;
b) the discrepancy between the languages and narrative forms used in schools and the need to develop new languages to support the imagination and face the contemporary challenges of today and tomorrow;
c) the distance between the a-temporal ways of presenting scientific knowledge and the need to develop, in young people, foresight, imaginative, and action competence skills.

More specifically, the first paper of the symposium will present the findings of four part-studies on the limits and advantages of organising knowledge into disciplines in educational institutions as well as the issues that such organisation erects to harvesting the advantages of inter-/multi-/trans-disciplinarity in science education. The evidence is used for constructing a framework for aligning science education in formal contexts with the modus operandi of R&I. The second paper presents the research that addressed the mismatch between the scientific languages used in the school and those that the students encounter out of school. This research led to the production of the "Framework for Unbound Languages". The framework consists of the description of key concepts that can convey the search for new languages to navigate unexplored territories and possible futures, and convey actions in our uncertain times. The third paper presents the main results of four part-studies investigating young people's perceptions of the future, agency and technology and an analysis of how future thinking is addressed in secondary school science curricula in five European countries. Based on these empirical results and extant literature, recommendations for 'futurizing' science education are provided in terms of suggestions to revise curricular contents, contexts and pedagogical methods. The final paper of this series focuses on consensus building as a step towards (re-)alignment. This paper explores policymakers' perspectives on future-oriented science education and ways of achieving them. Adopting a Delphi study design, a questionnaire was distributed in three rounds to policymakers in four European countries. Responses in each round informed the design of the questionnaire in the next round. The analyses summarised and iterated prevalent views among policymakers, eventually creating a common ground for further discussion. The results also provide useful references for other stakeholders on how science education can

prepare students for the future. All the papers, through a wide variety of methods and research foci, contribute to building a coherent picture of issues and recommendations. The recommendations have been informing implementations carried out in three openschooling networks and will, hopefully, contribute to the development of proactive and anticipatory educational policies at national and European levels.

357 Future-Oriented Model for Science Education – a Delphi Study on Policymakers' Perspectives

Jessica Chan[1], Olga Ioannidou[2], Sibel Erduran[1]

[1]University of Oxford, Oxford, United Kingdom. [2]University College Dublin, Dublin, Ireland

Abstract

If one overarching aim of science education is to build school systems that meet the needs of the society of acceleration and uncertainty, policymaking plays a key role in aligning schools with the society. This paper focuses on what future-oriented skills mean to policymakers in science education. Our objective is to build a common understanding among policymakers as part of the stakeholders, of what these skills are and how they can be realised. 35 policymakers from Finland, Italy, Lithuania and the UK have taken part in a Delphi study spread across two years. Data analyses involved both quantitative and qualitative methods. The first two rounds of a questionnaire administered to the policymakers suggested that they view problem solving, critical thinking and digital literacy as core elements of future-oriented skills. They also proposed an interdisciplinary approach to future-oriented science education so that students are able to deal with global crises in future. Implications of the study include further consensus building with other stakeholders, and identifying gaps between those visions, curriculum goals, assessment regimes and classroom practices in fostering future-oriented science education.

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435 Aligning Science Education in Formal Contexts with the Modus Operandi of R&I

Raminta Pucetaite[1], Olivia Levrini[2], Rimantas Rauleckas[1], Rasa Daugeliene[1], Donata Jovarauskiene[1]

[1]Kaunas University of Technology, Kaunas, Lithuania. [2]University of Bologna, Bologna, Italy

Abstract

The paper presents the findings of four studies on the limits and advantages of organising knowledge into disciplines in educational institutions as well as the issues that such organisation erects to harvesting the advantages of inter-/multi-/trans-disciplinarity in science education. Drawing on the research evidence about the advantages of both disciplinary and interdisciplinary approaches to science education and the ways of addressing the limits of present knowledge organisation the authors identify five issues related to science education and propose a set of recommendations for handling them, which is integrated into the

Framework for Aligning Science Teaching/Learning in Formal Contexts with the modus operandi of R&I. As a result, the framework consists of the issues named Divergence between de jure and de facto, Demands from teachers, Disciplinary isolation and lack of interdisciplinary language, Graduates unprepared for life, and Social insensitivity, which erect cognitive, emotional, epistemological, social-cultural boundaries or even barriers to promoting inter-/multi-/trans-disciplinarity in science education. The key recommendations include setting up a safe and emotionally positive trading zone as a location and institutional context that does not belong to any disciplinary context, enable merging new professional identities, designing a methodology to acknowledge uncertainty of one discipline to solve complex problems, developing the skills needed to accept the risk, embrace ambiguity and managing the equilibrium between sense making and "strange making" skills in a common coined language, auditing and redesigning organisational processes.

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708 Students' Perceptions of Future, Agency and Technology — Research-Based Implications for Science Education

Antti Laherto[1], Tapio Rasa[1], Eleonora Barelli[2], Erica Bol[3], Martina Caramaschi[2], Giulia Tasquier[2]

[1]University of Helsinki, Helsinki, Finland. [2]University of Bologna, Bologna, Italy. [3]Teach the Future, Amsterdam, Netherlands

Abstract

Global sustainability crises and accelerating societal and technological developments are posing new demands for science education research and practice. Taking responsible action and contributing to change have been taken up as important aims of school science. Such agency is deeply connected to how one orients towards the future. This paper investigates young people's perceptions of the future, agency and technology, and suggests how science education can provide students with tools for connecting with, and finding agency within, their personal and global futures. Almost 300 students' writings about their desirable futures were analysed from various perspectives in four part-studies of an EU project, employing qualitative content analysis and narrative inquiry. Several issues in students' futures thinking were identified: simplistic and non-problematised narratives of sociotechnical development, polarised attitudes, and a lack of imagination for alternatives and opportunities for agency. Besides the studies on students' perceptions, an analysis of secondary school science curricula from five European countries showed that curricula do not provide explicit support for students' perception of time and the future. On the basis of these empirical results and extant literature on young people's futures thinking, we propose recommendations for 'futurizing' science education by revising curricular contents, contexts and pedagogical methods. We conclude by discussing the relevance of the findings and recommendations for further development of science education fostering students' imagination and transformative agency towards the future.

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610 New Languages for Science Education: A Framework for an Active Exploration

Andrea Troncoso, Francesca Conti, Elisabetta Tola

Formicablu, Bologna, Italy

Abstract

There is a recognised need for new languages and formats to enhance imagination and the capacity to discuss contemporary challenges and find ways to describe, define, and face them with creative solutions. The call for societal transformations made by the United Nations' Agenda 2030 cannot be achieved without transgenerational thinking, responsibility and transformative agency of the young (Unesco, 2017). In this presentation, we will share the research that led to the production of the Framework for Unbound Languages. The purpose of this framework is to equip teachers, teacher trainers and their students with linguistic, argumentative and imaginative thinking skills useful to face contemporary challenges and to provide them with languages and conceptual tools to innovate and futurize science education. The framework illustrates key concepts when conceiving the four new language groups that will help better understand and better tune in with the requirements of contemporary societies. The new languages proposed want to convey actions to be deployed in different spaces, times, disciplines and contexts. These languages are the following:

- Languages for adaptation
- Languages for foraging futures
- Languages for uncharted territories
- Languages for interdependencies

The methodology included a benchmark study, a survey, focus groups and co-creation workshops with internal and external experts. Examples will be provided to deepen the discussion about the possibilities that this image provides for science education and its "futures" capacities.

Parallel Session - 3.13 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

6 Cross-Disciplinary STEM Learning for Asian Primary Students: Design, Practices and Outcomes

Chair

Winnie Wing Mui So

Discussant

Antuni Wiyarsi

Abstract

Science, Technology, Engineering and Mathematics (STEM) has continued to attract attention worldwide, and there have been calls for the promotion of STEM education in primary schools to nurture students to meet the needs of the societies in terms of their innovation and technology development. Despite considerable efforts made to promote STEM education in Asian communities in recent years, There has been a limited number of work to explore how integrated STEM teaching and learning is implemented in this context. Since STEM is complex in nature and is related to various disciplines, the effort of a single discipline may not be as effective as cross-disciplinary efforts. Given the importance of student learning in the various types and opportunities of STEM education offered for primary students, this symposium provides a landscape of cross-disciplinary STEM learning in Asian primary schools, and an overview of design, practices and outcomes of STEM learning implementation. This symposium, involving an Asian team of authors, will provide details on HOW cross-disciplinary STEM learning can be designed for students to achieve viable outcomes, and WHAT opportunities and challenges have been offered to our next generation to equip them with the necessary skills, knowledge, ways of thinking, as well as attitudes and values.

19 Taking the Lead in STEM: A Case Study of a Singapore Primary Science Teacher's Attempt at STEM

Yann Shiou Ong[1], Aik Ling Tan[2], Tang Wee Teo[2], Li Mei Johannah Soo[2], Timothy Ter Ming Tan[2]

[1]National Institute of Education, Nanyang Technological University, Singapore, Singapore. [2]National Institute of Education, Nanyang Technological University, Singapore, Singapore, Singapore

Abstract

The implementation of STEM is fraught with challenges for teachers as they struggle in the transformation from being a single disciplinary-based teacher to cross-disciplinary trailblazers. Since the 1960s, there have been reports on how teachers find it difficult to cope during times of curriculum reforms. The reasons are varied but the unwanted "side-effects" include teachers being deskilled and feeling dejected about the education system resulting in high turnovers. With the inundation of narratives about the promises of STEM education and how teachers need to adapt and prepare students for the 4th industrial revolution, how do teachers digest the narratives and take on this new challenge? What impact does this new wave of education goals have on primary science teachers who are mostly not trained in the STEM disciplines? This paper reports on a case study of a primary school teacher in Singapore who participated in a larger study and effort to introduce integrated STEM to his students. We followed the journey of this teacher who led a team of teachers in his school to learn, then teach, an integrated STEM curriculum that entails coding with humanistic outcomes. The findings illuminated his positive thinking about STEM teaching, the STEM capital he had harnessed to enact the curriculum, and ways he empowered himself to carry out the curriculum effectively. The findings could offer insights on the enablers of STEM curriculum making even as teacher agency is circumscribed by traditional disciplinary and personal structures.

22 The Influence of Cross-Disciplinary STEM Learning on Asian Primary Students: A Review of Empirical Studies

Zhi Hong Wan[1], Winnie Wing Mui So[1], Tiangyi Zhang[1], Tian Luo[2], Daoqing Xie[1]

[1]The Education Unviersity of Hong Kong, Hong Kong, China. [2]Capital Normal University, Tian Jin, China

Abstract

This paper reviewed 28 empirical studies conducted on the impacts of cross-disciplinary STEM learning activities on Asia primary students. Three kinds of evidence were found from these studies on the influence of cross-disciplinary STEM learning on asian primary students, i.e., pre-post comparison of the intervention studies on the impacts, teachers' views of the values of cross-disciplinary STEM learning, and students' experience of cross-disciplinary STEM learning. As indicated in the pre-post comparison of the intervention studies, cross-disciplinary STEM learning was found having significant impacts on subject knowledge (e.g., science knowledge, technology knowledge), subject skills (e.g., sequencing and repetition loop), higher-order thinking capacity and disposition (e.g., analysis/reasoning, creativity, critical thinking, and problem solving), social skills (e.g., collaborative thinking, environmental awareness), attitudes and career interest (e.g., attitude towards science, interest in engineering; career interest in STEM). Comparing the impacts of different STEM learning activities indicates that comprehensive approach produced the most significant impacts on Asian primary students. It was also found that cross-disciplinary STEM learning activities had stronger impact on affective learning outcomes (such as attitude towards learning and career interest) than cognitive learning outcomes (such as knowledge, subject skills, and thinking). The research on primary teachers' views of the values of cross-disciplinary STEM learning revealed 5 four broad

categories on the values relevant to students, including subject knowledge, higher-order thinking, social skills, attitudes and career interest. Among these categories, more attention was paid by teachers on the development of high-order thinking. Echoing the findings of previous two types of evidence, the research on students' own experience of cross-disciplinary STEM learning also revealed the influence of cross-disciplinary STEM learning on subject knowledge, higher-order thinking, social skills, and attitudes towards learning. However, students were found to mention more about their attitude aspects, such as enjoyment and interest during STEM learning.

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158 STEM Education for Primary Schools: A Topic Modeling Study of STEM Applied Learning Programmes Websites in Singapore

Eunjeong Yun[1], Yann Shiou Ong[2], Yew-Jin Lee[2]

[1]Kyungpook National University, Daegu, Korea, Republic of. [2]National Institute of Education, Singapore, Singapore

Abstract

STEM education is increasingly viewed as a means of raising long-term interest and achievement in associated school subjects although consensus has not been reached regarding its exact composition of disciplines and organization. In Singapore, STEM predominantly occurs within the context of school-based STEM Applied Learning Programmes (ALP) among primary and secondary schools here. Based on analysing STEM ALP websites (N = 42) from primary schools (Grades 1- 6), we uncover how these schools self-describe their STEM education programs, to understand what passes for STEM education here. The textual data from the websites was first analysed using unsupervised topic modeling to uncover frequently occurring as well as unique words/ expressions associated with the descriptions of STEM ALP. We then used these words/expressions to inform topic tags for carrying out supervised topic classification by subject experts. It was found that many STEM ALP at primary levels identified themselves with two out of five Singapore Ministry of Education recommended themes - game design & making and sustainability. In addition, inferences will be drawn regarding the learning approaches promoted (i.e. inquiry-based, design-oriented, or innovation-driven) through these STEM ALP websites. Implications concerning the variations in learning approaches among schools will be discussed.

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689 Scaffolds for Educators for Designing STEM Activities: A Review of the Frameworks in STEM Education in Asia

Yingying Zhou[1], Tian Luo[2], Qi Huang[3], Xuan Huang[4], Winnie Wing Mui So[5], Zhi Hong Wan[5]

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Abstract

With the rapid development of STEM (the acronym of science, technology, engineering, and mathematics) education, the importance of conceptual frameworks to facilitate teachers' design and implementation of STEM activities (activities in STEM lessons, curriculum, and other learning opportunities) has been highlighted. Frameworks could help teachers, especially teachers who are new to STEM education, to construct and design learning objectives and plan their teaching. This study provides an overview of the different frameworks in STEM education developed by educators in Asia that could facilitate teacher lesson planning and implementation. The frameworks reviewed range from those proposed in official documents by education administration sectors to those developed by researchers and educators. Descriptions of examples of these frameworks have also been provided where available. We compared the reviewed frameworks and classified them into micro (usually dealing with classroom-level or pedagogical issues), meso (usually less detailed but may be very helpful for curriculum development), and macro (usually help to guide the arrangement of a group of different curricula or a multi-year plan of STEM curricula) levels. The study also summarizes other features, including but not limited to integration level/mode, implementation strategy and evaluation, for each framework, and proposes future directions for this field of study.

Parallel Session - 3.14 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

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33 Exploring Critical Thinking in Design Based Pedagogy: Cases From European Teacher Education Programs

Chair

İbrahim Delen

Discussant

Maria Evagorou

Abstract

Problem based learning (PBL) has been an important component of higher education for decades (Perrenet et al., 2000). PBL aims to support students' critical thinking (CT) and acquisition of subject knowledge (Sendag & Odabasi, 2009) while supporting inquiry related practices (Srinivasan et al., 2007). The idea that students should actively engage in inquiry practices to gain new knowledge is the cornerstone of problem-based learning (Hmelo-Silver, 2004; Perrenet et al., 2000). One method of problem-based learning focuses on issues that

require the creation of a design product in order to be resolved (Hmelo et al., 2000). However, Ehsan and Cardella (2020) emphasized that design-based learning is still in the exploratory stage and Royalty (2018) added that teaching design to non-designers require supporting a design based pedagogy. In addition, Puig et al. (2021) found design based learning studies present few examples investigating CT. Departing from the dearth of studies exploring this connection, four European teacher education programs in the the Netherlands, Spain, Italy and Turkey started a joint ERASMUS+ project and developed an activity and assessment framework to support design based pedagogy during numerous online and face to face meetings. During the symposium partners will elaborate on how they developed the activity framework to support CT in design based pedagogy. All partners implemented activities created based on the joint framework and analysed design practices using the common rubric. The rubric used in all studies evaluated CT by examining seven dimensions:

A- Selecting design constraints- How did pre-service teachers (PSTs) define limitations of design?

B- Defining design parameters- How did PSTs define variables related to design?

C- Finding evidence related to design parameters- How did PSTs include evidence related to design parameters?

D- Defining (implicit) criteria for deciding which design is better- How did PSTs discussing connections between parameters and evidence?

E- Identifying materials & tools to creating the prototype- How did PSTs identify different materials & tools to create the prototype?

F- Defining how the prototype satisfies original goal- How did PSTs discuss the prototype satisfies original goal?

G- Defining how to improve the design product- How did PSTs present aspects that could be improved in the design product?

The Dutch case reviewed student design reports as they were working on separate design challenges in 'Designing STEM Education' course. The Spanish case presents how CT was represented in a design process that involves PSTs engaging in an emerging socio-scientific problem during a methods course. The Turkish case supported PSTs using 3D printers and work in interdisciplinary teams in a laboratory course. Finally, Italian case asked PSTs to create a musical instrument by using recycled materials in an online course. All of these cases supported CT in different contexts and they present great examples to discuss how to support CT and design based learning in various courses. When we look at the frequency of CT skills, design reports included a greater number of CT skills in the Dutch case. Dutch STEM PSTs are engaged in different tasks during their training. This could serve as an evidence that more opportunities for PSTs may lead a better understanding of CT skills. As stated in the Spanish case, demands of the design activity have an effect on the CT skills. Several CT skills were not evident due to task. Connected with this result, creating physical design products in Turkish (thermos design) and Italian (musical instrument design) supported PSTs having a higher

frequency when finding evidence related to design parameters.During the symposium, each case will be elaborated by presenting design activities and design products from each country discuss finding better ways to support CT in design pedagogy.

462 Exploring Critical Thinking While Using 3D Printers in Interdisciplinary Pre-Service Teacher Teams

Gul Unal Coban, Ercan Akpinar, Elif Bugra Kuzu Demir, Erkan Ozcan, Yasemin Kahyaoglu Erdogmus

Dokuz Eylul University, Izmir, Turkey

Abstract

Design based pedagogy has gained importance in recent years. This study focuses on how design based practices support critical thinking (CT) skills of pre-service teachers (PSTs). This study is a qualitative case study including implementation conducted with 56 PSTs having Science Laboratory Course. PSTs participated in the study voluntarily and worked in groups of 3 to 4. PSTs were expected to design and build a thermos first using water bottle and then using 3D printer prototype with insulation materials they chose. Implementation of this study consisted of design challenge which was based on designing a product (designing and building a thermos). The worksheets filled by PSTs' were the main data collection toll. Data was analyzed qualitatively by two researchers. As a result, five CT skills (explanation (13), inference (7), interpretation (6) and evaluation (7), analysis (2)) were identified in PSTs written answers. Moreover, it has been determined that teacher candidates have different CT dispositions such as "Systematicity & Analyticity, Open-Mindness, Inquisitiveness, Truth-s Seeking, Self Confidence and Inquisitiveness" regarding different design dimensions in the thermos activity. Considering the results, it can be said that the critical thinking skills of pre-service teachers improved with critical disposition in the process of designing thermos activities and developing the product.

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395 Exploring Critical Thinking when Engaging Pre-service Teachers with an Emergent Socio-scientific Issue

Blanca Puig, Beatriz Crujeiras Pérez, Paloma Blanco Anaya

University of Santiago de Compostela, Santiago de Compostela, Galicia, Spain

Abstract

This study addresses the analysis of critical thinking in a design-based activity that requires the design of a model (artefact) that helps to mitigate the effects of sea level rise in a specific location. The research questions are: 1) How is CT displayed in a design process that engages students in scientific practices to solve a STEM problem linked with an emergent socio-scientific issue? 2) How CT evolves during this design process? Specifically, how CT is linked with the diverse stages of the design process? The participants were a group of primary prese-service

teachers engaged in socio-scientific instruction. The design challenge involved different stages carried out in four sessions in which participants were required to integrate knowledge from diverse domains as well as to articulate critical thinking and scientific practices. Methods applied correspond to content analysis of students' oral interventions. Results show that CT was activated during the design process, being "select design constraints" the design stage that enhanced more skills compare to others. CT differs in terms of the type of skills and dispositions that emerge during the design activity. The findings suggest that the cognitive demands of the design activity and the scientific knowledge involved might influence CT development.

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419 Exploring Critical Thinking Skills of Dutch STEM Pre-Service Teachers

Dury Durdane Bayram-Jacobs, Ruurd Taconis, Elise Quant

Eindhoven University of Technology, Eindhoven, Netherlands

Abstract

To be able to develop the critical thinking (CT) skills of future engineers and scientists, teachers should be competent in these skills and in teaching them. Therefore, in teacher education programmes, when preparing a learning environment for implementing design challenges and products, developing pre-service teachers' CT skills need more attention. The aim of this research was to explore the CT skills of Dutch STEM pre-service teachers while they design for a design challenge from a secondary education context. We explored the development of CT skills in each design dimension. CT is not explicit in the design course, but they are embedded in the design process. Hence, we can conclude that the course and the template of the design reports supported PSTs in developing CT skills.

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538 Exploring Critical Thinking When Supporting Design Based Pedagogy in an Online Learning Environment

Eleonora Concina[1], Sara Frate[1], Gul Unal Coban[2], Michele Biasutti[1]

[1]University of Padua, Padua, Italy. [2]Dokuz Eylul University, Izmir, Turkey

Abstract

The study analyses the critical thinking emerging during a design activity in an online environment. Six university student teachers were asked to plan and build a musical instrument using recycled materials. Both the design product and the participants' learning processes were examined. A content analysis was applied to the online interactions of the participants using the framework of Critical cognitive thinking skills. In the design activity, pre-service teachers did not define many parameters but defining evidence relevant to design parameters was the most frequently employed dimension. This could be related to pre-service teachers working together in groups and supporting teamwork during the design activity. The results show that the critical thinking skills most used in an online environment was evaluation and working in groups supported self-regulation.

1074 Exploring Students' Systems Thinking and Perceptions on Complex Health Issues

Blanca Puig[1], Araitz Uskola[2], Inés Martínez Pena[1]

[1]Universidade de Santiago de Compostela, Santiago de Compostela, Galicia, Spain. [2]Universidad del País Vasco, Bilbao, País Vasco, Spain

Abstract

The current and future environmental and health problems humans face requires scientifically literate citizens ready to take responsible actions. Systems thinking is an essential skill to understand complex health issues, to make predictions and to empower students to take critical actions. This study seeks to explore how students apply ST in a complex health issue related to COVID-19 pandemic and how they perceive the possibility to anticipate future pandemics and the relationship of this perception with actions they propose to prevent them. The research questions that guide this study are: RQ1. What ST level do secondary education students show when identifying causes for the origin of pandemics; RQ2. To what extent do secondary education students perceive that citizens can anticipate epidemics? And in what way is this perception linked to their action proposals for preventing them? The participants were 18 secondary school students involved in diverse activities about infections and pandemics that included three case studies about zoonosis in their biology instruction. Written individual answers of a task about pandemics were analyzed using content analysis methods. Results show that students were able to identify that could potentially explain the origin of the COVID-19 linked to human and animal health, however, none pointed to environmental factors. They showed simple causal thinking rather than ST, since they were not able to connect the three dimensions of One Health notion. The actions proposed to prevent future pandemics are mitigating and immediate actions rather than preventive and sustainable actions. Moreover, a negative perception on the prediction of future pandemics seems to inactive students for proposing actions to prevent them. Science educators need to invest time and efforts to design activities to engage students in future thinking to enable them to see themselves as agents of change and acting responsibly.

Parallel Session - 3.15 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

62 Addressing Science-related Career Awareness through a Horizon 2020 Project Framework

Chair

Miia Rannikmäe

Discussant

Jack Holbrook

Abstract

This symposium seeks to address a major concern related to the role of science researchers and the academic training of science education researchers, currently deemed insufficient to reflect on the combination of expertise needed in educational research, the making of science teaching careers attractive for students and the promoting of other science-related careers through encouraging attractive science teaching in schools. Academic training, offered to prospective teachers in science-related fields, is seen as needing to go beyond the science conceptualizations and reflect context-based approaches, responsible research and innovation (RRI) aspects, digital learning as well as assessment strategies, particularly with respect to combining these aspects with career awareness. The necessity to develop science-related competences, linked to promoting science-related career awareness, has acquired increasing leverage in the light of recent global socio-economic developments, calling for more sustainable, environmentally friendly, ecological solutions, etc. plus associated actions in all walks of life. A major objective is thus to create a centre of excellence for the Baltic and Eastern European countries, promoting science career awareness. This is especially the case as Universities have recognised that the number of students undertaking STEM-related teacher courses is declining and that the STEM teacher profession is not being made popular among graduates. The 1st paper focuses on the need to minimise the gap between the beliefs of scientists and those of science education staff, plus an appreciation of the need for greater understanding of the differences between science and science education research. The study seeks to create a validated staff development model, related to both science and science education researchers. The model is developed from undertaking a SWOT analysis, based on self-determination theory and being internationally evaluated. The 2nd paper draws attention to the need to examine the potential for tailoring learning materials to match the learners' career aspirations and allowing them choose which career context is to be used for learning. To this end, it examines whether making science lessons more relevant to students' career aspirations can increase their interest in science. Using a 3-armed approach to study the effect of learning chemistry in the context of a specific career, the paper discusses the implications of

learning chemistry by choosing a career context in relation to personalized learning theory. The 3rd paper discusses the value of joint PhD seminars in science education through collaboration between three countries. Through the identification of common aims, the structure for a series of seminars is designed, based on research topics in PhD education. Within the seminars, the students prepare a four-page, draft research article, collaboratively review an article of a student from other country and then prepare a group seminar presentation based on the feedback. The students indicate that the international formal and informal collaboration most supported their learning as PhD students. The 4th paper recognises that an important goal of school science teaching and learning is to promote students' willingness and preparedness for science-related careers. It further recognises that an important goal for school science teaching and learning is to promote students' willingness and preparedness to be able to pursue science-related careers. The project seeks to determine students' self-efficacy towards the gaining of transversal competences, seen as important for potential future science-related careers. The study seeks to identify the valued transversal competences, interconnections among the competences, and also students' self-efficacy towards such competences, with respect to their recognition and value of science-related careers.

930 Developing and Evaluating a Model to Promote Science-Related Career Awareness - Minimizing the Gap Between the Science and Science Education Communities

Miia Rannikmäe[1], Jari Lavonen[2], Rachel Mamlok-Naaman[3]

[1]University of Tartu, Tartu, Estonia. [2]University of Helsinki, Helsinki, Finland. [3]Weizmann Institute of Science, Rehovot, Israel

Abstract

Education systems worldwide strive to enable a capable workforce, yet universities recognize the declining interest among students in undertaking STEM-related teacher courses and the lack of popularity of STEM teacher profession among graduates. Seeking to minimise the gap between the beliefs of scientists and those of science education staff plus an appreciation of the need for greater understanding of differences between science and science education research, a staff development model is developed from undertaking a SWOT, based on self-determination theory and internationally evaluated. The model is geared to both science and science education researchers, having a focus on promoting STEM related career awareness among STEM students. Outcomes, based on staff interviews, indicate science staff gain a greater conceptualisation of science education, especially in promoting career awareness and also an appreciation of differences between science and science education research, while science education staff gained a greater awareness of updated science trends.

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932 Transversal Competences for Science-Related Careers: Dimensions, Interconnections and Students' Self-Efficacy

Tapashi Binte Mahmud ChowdHURY, Janari Teessar, Miia Rannikmäe, Regina Soobard

University of Tartu, Tartu, Estonia

Abstract

An important goal of school science teaching and learning is to promote students' willingness and preparedness for science-related careers. In so doing, there is a need to promote competences which extend beyond disciplinary boundaries, and enable students to resolve complex problems with an integrated set of knowledge, skills, values and attitudes (i.e., transversal competences). The purpose of this research is to identify school students' self-efficacy towards transversal competences for potential future science-related careers. In so doing, the research develops an instrument which is built on a transversal competence framework. Expert validation, Cronbach Alpha and confirmatory factor analysis are sought through a pilot study to establish the validity and reliability of the instrument. The implication of this study relates to identifying the transversal competences, interconnections among the competences, and also students' self-efficacy towards such competences with respect to their science-related careers. The significance of the study is a theoretically justified instrument, which is valid, reliable and usable in future research in different contexts.

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942 Capacity Building in Science Education Research Through Joint International PhD Seminars

Jari Lavonen[1], Regina Soobard[2], Miia Rannikmäe[2]

[1]University of Helsinki, Helsinki, Finland. [2]University of Tartu, Tartu, Estonia

Abstract

This article discusses the development of joint PhD seminars in science education in collaboration with three countries. First, common aims and structure for an international PhD seminar series were designed based on research on PhD education. The students prepared four page draft research article, reviewed an article of a student from other country and then prepared a seminar presentation based on the feedback. During the seminar there were a couple of plenaries and PhD students' presentations. The students work also as opponents. The program was designed in way there were several possibilities for networking and informal learning together with other students and supervisors. The students were asked to evaluate their learning through answering a questionnaire, which was designed according to research on formal and informal learning as a part of formal PhD studies. Moreover, the students were interviewed. The students emphasized that international formal and informal collaboration supported most their learning as a PhD students.

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971 Learning Chemistry Through a Career-Focused Context: Letting Students Choose in Order to Improve their Interest

Yael Feldman-Maggor, Tal Hirsh-Sameach, Giora Alexandron, Ron Blonder

Weizmann Institute of Science, Rehovot, Israel

Abstract

Teaching strategies that implement a Personalizing Learning approach usually aim to match learning materials to students' different cognitive abilities. The goal of this research was to examine the possibility of tailoring learning materials to match learners' career aspirations and letting them choose which career context they want to use for learning. To this end, we examined whether making science lessons more relevant to students' career aspirations could increase their interest in science. We designed a three-armed controlled study to determine the effect of learning chemistry in the context of a specific career. Students in GroupA were free to choose one out of four optional career contexts (medical doctor, nutritionist, engineer, or artist) through which they could study ionic materials. Students in GroupB were randomly assigned a career context, whereas students in GroupC learned traditional chemistry lessons with no connection to a specific career context. To evaluate students' interests, we used two theoretical frameworks: The first is a 4-phase model of interest development: it triggered situational interest, maintained situational interest, triggered emerging individual interest, and developed individual interest. The second framework is the science self-concept theory. Students completed a pre-post questionnaire to evaluate their career aspirations, their level of interest in chemistry, and their self-concepts in chemistry. The preliminary results from a pilot study of 205 students indicated that situational interest increased for students in both GroupA and GroupB. However, the findings also indicated that when students learn through their career aspiration interest, interest in learning chemistry increases in a few dimensions and not only in situational interest. In this symposium session, we will present results from the complete study, which is still under analysis. Finally, we will discuss the implications of learning chemistry by choosing a career context in relation to personalized learning theory.

Parallel Session - 3.16 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

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44 Non-Hegemonic Sustainability in the Training of Science Teachers and Environmental Educators

Chairs

Laísa Freire, Mariona Espinet

Discussant

Arnau Amat

Abstract

Post-development perspectives of sustainability emerge in both the Global North and the Global South. This symposium highlights different foci that can emerge when teaching non-

hegemonic sustainability in the training of science teachers and environmental educators oriented towards the development of a praxis engaged to overcome socioenvironmental crisis. It aims at exploring: (a) What are the meanings of sustainability that emerge in the training of science teachers and environmental educators, and how do social attributes influence their practices or discourses? and (b) How can science teachers and environmental educators be prepared to address non-hegemonic sustainability and post-development issues to overcome Anthropocene while considering the unique socioenvironmental challenges in the Global North and South? The four contributions are located in Ibero-America and approach these questions using a diversity of contexts, concepts, and methodologies. The first contribution from Brazil examines the discursive hybridizations between the concepts of development and post-development in the sustainability discourses of environmental educators and teachers who conduct educational activities in the National Forest of Carajás in the Amazon rainforest. The 2nd contribution from Catalonia, Spain focuses on environmental science students' experiences when participating in an innovative teaching methodology grounded on the values of non-hegemonic sustainability that merges service learning and co-operatives for learning about environmental education. The 3rd contribution from Mexico reports on school gardens as an educational and community activity to move towards non-hegemonic sustainability in semi-urban populations of Jalisco, Mexico, exposed a sort of highly toxic pesticides. The 4th contribution from Chile examines critical scientific and environmental literacies through a qualitative and systematic critical literature review and outdoor activities in a Chilean national park. The symposium will end with a discussion on the conceptual and methodological challenges for research on the introduction of non-hegemonic sustainability in the training of science teachers and environmental educators.

418 Post-Development Perspectives of Sustainability in Discourses of Environmental Educators and Teachers

Laísa Freire, Tainá Figueroa Figueiredo, Carolina Andrade da Silva, Reinaldo Luiz Bozelli

Federal University of Rio de Janeiro, Rio de Janeiro, Rio de Janeiro, Brazil

Abstract

Post-development perspectives of sustainability are visions that emerge in contemporary life. The main objective of this research was to identify discursive hybridisms between notions of development and post-development in the discourses on sustainability of environmental educators and teachers, using discourse analysis as a theoretical framework. We analyzed 47 texts produced by environmental educators and teachers in four in-service formation courses over the years 2018, 2019, and 2021. We identified that sustainability hegemonic discourses are present in the text as well as non-hegemonic perspectives. Hegemonic discourses are characterized by a view of nature as a resource to be explored, with the idea of environmental care being subordinated to the quality of human life and a sense of human distance and non-inclusion in nature. Some hybridisms and contradictions in the educators' discourses occur through recognizing a human being as part of nature while identifying the Amazonian territory

as suffering from destruction by human being, assuming a vision of itself separately from nature. Through the analysis, we have perceived that most of the non-hegemonic sustainability discourses occur in the texts written during the pedagogical activity in the forest after the walking on the trail. Being in the forest, and having contact with non-urbanized environments is an important path for the emergence of non-hegemonic sustainability senses.

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437 Critical Scientific and Environmental Literacies: Non-Hegemonic Sustainability Education From Outdoor Science Education

Gonzalo Guerrero

Institut of Education, University College London, London, United Kingdom

Abstract

In a global context of planetary climate crisis, scientific and environmental literacies have a key role towards transformation and climate action. Within the so-called formal education system, environmental literacy most frequently finds a home within science education, explaining the almost universal assumption within environmental literacy resources that more knowledge than common sense is needed. For some authors, scientific literacy provides the language for the argumentation of ecological or climate action and the promotion of critical approaches in environmental education. For instance, science concepts and models are essential to understanding climate change. However, paradoxically, for some authors from Global South, the hegemonic scientific literacy definition is the reason for the disconnection from the natural world. Therefore, as long as we do not advance to a critical and non-hegemonic vision of sustainability education in tune with an eco-centric approach, the visions of environmental literacy will have failed. Envisioning possibilities in action, this proposal presents two stages of a PhD project aimed at answering two research questions: How have science education scholars from the Global South understood critical scientific and environmental literacies? How can we promote a non-hegemonic critical scientific and environmental literacy approach from outdoor science education? At answering the first research question – methodologically from a systematic review of literature of the last three decades– I evidence tensions among different hegemonic and non-hegemonic paradigms, and conceptualisations for both concepts (scientific and environmental literacy), especially in the last decade where decolonial approaches emerged. Regarding the second question, the foregoing imbalance raises challenges in developing collaborative outdoor science activities. Findings show tensions and challenges between science educators and pre- and in-service science teachers' discourses to promote critical literacies in outdoor science education. However, after collaboration developing a field trip, dialogue evolved towards understanding our interdependence with nature and not as a false human-nature dichotomy.

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443 School gardens as an educational and community activity to move towards non-hegemonic sustainability

Silvia Lizette Ramos de Robles[1], Irma Aidé García Villegas[1], Claudia Lizeth Huerta Rodea[2]

[1]Guadalajara University, Guadalajara, Jalisco, Mexico. [2]Instituto Superior de Investigación y Docencia para el Magisterio, Guadalajara, Jalisco, Mexico

Abstract

This study proposes the school garden as an educational and community strategy to build non-hegemonic sustainability and healthy lifestyles. This proposal is the response to agro-industrial practices, which from a hegemonic perspective of production, resort to the excessive use of highly toxic pesticides, favouring economic aspects and putting ecosystems and human health at risk. We used a mixed method approach with a sequential explanatory strategy in which a quantitative diagnosis was first developed, and later, an educational strategy using a qualitative perspective. In both phases, we work with preschool children and their mothers in semi-urban populations of the state of Jalisco, Mexico. In the first phase, we identified the fruits and vegetables most consumed by the children and then we analyzed the presence and concentration of pesticides through Liquid Chromatography/Electrospray Ionization-Tandem Mass Spectrometry. Pesticides were found in 87% of the samples; some were highly toxic (neonicotinoids) and harmful to human health. In the second phase, we work through learning activities in the school garden. Video recordings, interviews, and drawings of the students were realized, and analyzed using an interpretive perspective –applying conversational analysis and compositional interpretations (for the drawings)-. The results show that the students have little or no knowledge about the importance of soil and its' functions. Children consider the seed and the plant as two independent entities. Additionally, students learned about the origin of food and the importance of harvesting and eating healthy. The garden became a collaborative learning activity between teachers, students, and parents, in which self-consumption and food production are valued as sustainable practices. As part of a non-hegemonic view of sustainability the principles of food sovereignty were strengthened, emphasizing how the garden allows attender the diverse perspectives and needs of different communities, rather than imposing a one-size-fits-all solution from the top down.

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444 Teaching Non-Hegemonic Sustainability Through Co-Operatives for Learning: The Voice of Students From Environmental Sciences

Mariona Espinet[1], German Llerena[2], Laísa Freire[3], Silvia Lizette Ramos de Robles[4]

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Abstract

Non-hegemonic sustainability perspectives present sustainability alternatives rejecting unlimited growth on a finite planet and addressing social inequalities as well as social justice. The teaching of non-hegemonic sustainability in higher education requires pedagogical changes affecting curriculum, teaching methodologies and classroom organization. We argue that teaching methodologies such as co-operatives for learning, framed with degrowth epistemological visions, promote the development of students' non-hegemonic sustainability cosmovision and environmental praxis. The research context is a public university in Catalonia (Spain) implementing a teaching methodology merging service learning and co-operatives for learning Environmental Education in an Environmental Sciences degree during the pandemic academic year 2020-21. The research question is: What are the experiences of undergraduate students participating in co-operatives for learning about environmental education? Data was collected collaboratively using two complementary techniques such as virtual group interviews and students' individual reflective narratives. The use of an inductive thematic analysis framed through the sociocultural construct of dialectical tensions lead us to the identification of 14 dialectical tensions organized in 7 different dimensions. We conclude our contribution by identifying three breaking points for the transition to teaching non-hegemonic sustainability using co-operatives for learning in an Environmental Sciences degree: (a) de-commodification of work (tradition/innovation; theory/practice); (b) reconstruction of relationships with "the other" (individual/collective); and (c) reconstruction of relationships with nature (capitalism/degrowth).

Parallel Session - 3.18 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

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43 Scientific Explanations in Science Education Research

Chair

Steffen Wagner

Discussant

Tommi Kokkonen

Abstract

Scientific explanations are crucial for doing and learning science. They are relevant in all scientific disciplines. Learners and scientists create their own and use given written and pictorial representations to explain natural phenomena. Therefore, firstly, providing learners with good support in creating explanations is essential. Secondly, explanations must be analysed as comprehensively as possible, in different scientific domains, at different representational levels and for different target groups to be able to assess the effectiveness of support and the quality

of learners' explanations. And thirdly, learners and teachers need to be able to deal with given explanations with pictorial and written elements such as in textbooks. The aim of the symposium is, therefore, to bring together these different perspectives on explanations. To this end, author 1 presents an approach for a fine-grained structural analysis of pictorial components of explanations and applies this so-called *Elementary Structure* approach to drawings of pre-service teachers' explanations of a phenomenon of the seasons. The method has already been shown to be suitable for the precise analysis of written explanations, and a transfer to drawings allows both forms of representation to be studied jointly at a fine-grained level. At this level, the study can help to precisely identify which elements cause difficulties. Author 2 looks at the written scientific explanations of the same participants as author 1 and analyses them with the help of a level-based category system called *System of Analysis*. This category system has also proven successful for written explanations, but in a different domain, chemistry. The results show the strengths and shortcomings in the participants' reasoning, especially in linking the underlying mechanism to the phenomenon under explanation. The different approaches of authors 1 and 2 - fine-grained analysis of the drawings and level-based analysis of the corresponding written explanations - can be compared, and potential connections of the results can be debated in the symposium discussion. Author 3 uses the System of Analysis of Author 2 to investigate students' scientific explanations in different domains. The explanations were based on pictorial representations given to the participants. The results reveal how appropriate support using the *Thinking Frames Approach* helps students use logical chains in the explanations. Author 4 uses the framework of socio-semiotics to analyse the function of such pictorial representations and how they support written explanations, in this case, diagrams in textbooks for grades 7-10, showing, for example, that diagrams for scientific explanations are different from visual representations in other genres and what this means for learning. Here, Author 1's fine-grained elementary structure approach, for example, could contribute to deepening the analysis by examining which pictorial elements are used in the written explanation and how. The four authors thus illuminate scientific explanations from four different perspectives and various sources: students, pre-service teachers, and textbooks. They explicitly consider the multimodal nature of explanations and can contribute to a holistic understanding of how explanations can be analysed and supported with complementary approaches. This is an essential contribution to supporting learners in the crucial practice of creating scientific explanations and supporting researchers in carefully selecting appropriate strategies for investigating scientific explanations.

388 Analysing Drawings From Explanations for a Seasonal Phenomenon

Steffen Wagner

Humboldt-Universität zu Berlin, Berlin, Germany

Abstract

Drawings are helpful tools for sense-making in science. So far, there is no approach to systematically analyse the basic elements and their relations in both drawings and written

explanations. However, there is an approach for analysing written explanations on a fine-grained level, the Elementary Structure (ES) framework, whose applicability to drawings is presented. For this purpose, 124 preservice teachers were asked to complete drawings on a phenomenon in the context of the seasons. These were decomposed using a procedure based on the ES framework. Most learners complete the task adequately. However, they have difficulties, mainly when they use elements that might be taken from other sources that are irrelevant to explaining the seasonal phenomenon and whose meaning is unclear to them. The results show that the framework can be successfully applied to drawings and allows a meaningful analysis of their basic elements. Next, it remains to be examined how the procedure works for the synchronous study of drawn and written parts of explanations about the same phenomenon.

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389 Drawing on the Idea of Thinking in Levels to Revisit an Analytical Framework for Mechanistic Explanations Across Science Domains

Vanessa de Andrade

Universidade de Lisboa, Lisbon, Portugal

Abstract

From the many forms that scientific explanations may take, mechanistic explanations have been valued in science and inscience education, for their explanatory power. Hence, several frameworks have been proposed to analyse and characterise students' mechanistic explanations. These frameworks have mainly emerged from studies within the domainof chemistry and biology. Thus far, studies focused on physical phenomena, astronomical in particular, are scarce. Considering this, I revisited an existing analytical framework developed in the context of chemistry and refined it for allowing to characterise mechanistic explanations across different scientific domains. With this paper, I aim to present the refined analytical framework, illustrating it with examples of pre-service teachers' explanations about the length of the day-night cycle. I expect to highlight how the framework offers progressive explanatory levels to characterise explanations across scientific domains regarding their mechanistic sophistication. In addition, I explore the epistemic reasoning underlying each explanatory level.

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392 Supporting Grade 8-10 Students to Write Scientific Explanations: The Thinking Frames Approach

Felicity McLure

Charles Darwin University, Darwin, Australia

Abstract

Writing causal scientific explanations of observed phenomena is challenging for middle school and high school students and they tend to write descriptions of what they observed without making causal links with underlying scientific models. Despite the need to explicitly guide students in constructing scientific explanations, few studies have described approaches that

support students in developing these writing skills. This study examines the efficacy of a multidimensional conceptual change approach, the Thinking Frames Approach (TFA) in developing students' ability to construct elaborated causal explanations. The approach scaffolds student construction of explanations through an iterative process as they socially construct verbal explanations, improve those verbal explanations through dialogic interactions with the teacher and then transfer their understanding into a series of explanatory diagrams. These diagrams are then used as a springboard for producing a written explanation which is evaluated against a rubric which identifies essential elements of a complex scientific explanation. Written explanations produced by 125 Grade 8-10 students learning physics, chemistry, and biology topics through the TFA were collected over nine-month periods. Explanations were evaluated using an analysis system for student explanations developed by de Andrade et al. (2019). Comparison between students' written explanations at the start and the end of the learning period revealed significant improvement in students' use of logical chains of reasoning which were connected to an underlying theoretical scientific model. In addition, students expressed an increased confidence in their ability to write scientific explanations.

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393 Characteristics of Diagrams in Scientific Explanations: Findings from Multimodal Textbook Analysis

Kok-Sing Tang

Curtin University, Perth, Australia

Abstract

There is a growing research examining the use of visual diagrams in scientific explanations. However, there are few systematic studies examining how diagrams are used in scientific explanations across a range of scientific texts. The aim of this study is to investigate the characteristics of explanatory diagrams found in grade 7-10 science textbooks covering many topics in biology, chemistry, earth and space sciences, and physics. The study is informed by the theory of social semiotics and applies a mixed methods approach to textbook analysis. A content analysis was first carried out to systematically identify the image functions (e.g., narrative, analytical, temporal) in all the diagrams (N=749) and compare their distributions across different genres (e.g., explanation, information, experiment). This is followed by a multimodal discourse analysis to understand how the various image functions are combined with the linguistic features of the written text based on a heuristic framework of scientific explanation called premise-reasoning-outcome (PRO). Quantitative results reveal explanation diagrams are characteristically different from diagrams used in other genres in terms of a higher usage of narrative function, temporal function, and annotated caption. Qualitative results further show how these image functions are typically used to support the reasoning of the explanation focusing on dynamic processes and time-bounded sequences. This study has implications to how we can support students in constructing scientific explanations that often include multiple visual representations.

Parallel Session - 3.19 (Symposium)

09:00 - 11:00 Tuesday, 29th August, 2023

48 Climate Change and Science Education. Embedding a Transformative Dimension when Learning and Teaching Climate Change

Chair

Johanna Kranz, Petra Breitenmoser

Discussant

Antti Laherto

Abstract

The window of opportunity for effective mitigation and adaptation to the climate crisis is rapidly closing, whilst learners at all school levels have to deal with this significant challenge to both their present and future living environment. Despite the fact that many researchers attribute science education a pivotal role in a climate just transition, science at school still seems to fail in being supportive for students' making sense of these demanding socio-scientific issues related to climate change. Besides promoting a scientific knowledge base, many educational programs aim at changing students' individual behaviour through promoting awareness of the causes and consequences of climate change. However, such private-sphere actions seem to be insufficient to reduce greenhouse gas emissions sufficiently and to initiate required adaptation strategies needed. That is why it is necessary to account for the most effective strategies aiming not only at the private- but also the public-sphere to instigate political action. Science education in particular will need to offer the tools to do so by explaining the scientific facts, but also most effective collective pro-environmental actions in order to educate climate literate citizens that drive a climate just transformation. Thus, this symposium will lay the theoretical foundation and present empirical research on the transformative dimension supplementing learning and teaching about climate change in science education. The first paper examines the extent to which scientific findings and measures for climate change mitigation and adaptation are discussed in climate education programs in schools. The systematic literature review shows that current climate change education does not correspond with the climate research discourse. The authors demonstrate that effective mitigation and adaptation are based on collective/political and public-sphere actions and thus conclude that effective climate education should discuss those public actions if it is to be effective. To educate climate-literate citizens, the second paper centres on tools and instruments to support school students in transforming knowledge and experience to become change-agents in a socio-economic transformation. The results of the programme evaluation focus on different spheres of transformation, ranging from the individual to the political sphere, where both individuals and their institutional contexts change as participants gain agency. The third paper analyses the potential of ethics and justice to enable children to assess plural perspectives and to participate in decision-making for society as a whole. Through a problem-centred interview study, mental

models of primary school students are investigated. Results reveal that even young students are able to evaluate climate change in terms of climate ethics and justice theory, but concerning responsibility ethics, mostly individual and less collective-regulatory responsibilities of the political system are recognised. The fourth paper focuses on the statements of prospective primary teachers just before entering the profession on job-related and thematic requirements as well as contributing factors to teach climate change. Due to the complexity and controversy inherent to wicked problems, the primary teachers analysed in the study do not feel competent enough to teach climate change as a socio-scientific issue. This either leads to avoidance of the topic or reduction of the perceived difficulty by focusing on individual, political-neutral actions such as recycling, but without reflecting upon the underlying reasons. Overall, the contributions suggest to frame climate change as a socio-scientific issue, including not only scientific facts but also a transformative dimension in teaching and learning about climate change. Discussing identified challenges and potentials of science education across different perspectives conjointly helps to empower learners and their teachers as agents of value based transformative change.

448 What Do We Have to Relearn About Effective Climate Change Education? Results of a Literature Review

Johanna Kranz[1], Martin Schwichow[2], Petra Breitenmoser[3], Kai Niebert[4]

[1]Centre of Excellence for Climate Change Impacts, Trippstadt, Germany. [2]Department of Physics Education, University of Education, Freiburg, Germany. [3]Department of Primary Education, Zurich University of Teacher Education, Zurich, Switzerland. [4]Institute of Education, University of Zurich, Zurich, Switzerland

Abstract

Mitigating and adapting to climate change requires foundational transformation in societies, politics, and economies. To achieve these transformations political or public actions instead of individual behavior changes are necessary. Climate education thus needs to prepare students to participate in and reflect upon these political actions. However, little is known about how climate literacy programs address the political aspects of mitigation and adaptation. The aim of this systematic literature review is to fill this gap and analyze how public-sphere actions on mitigation and adaptation are discussed in climate literacy programs in schools. Based on database searches following PRISMA guidelines we identified 75 empirical studies that met our inclusion criteria. We found that central aspects of climate policy such as the 1.5-degree limit, the IPCC reports, or climate justice are rarely addressed. Whilst responsibility for emissions is attributed to the public sphere, the debate about mitigation usually focuses on the private sphere. Climate change education does not, therefore, correspond to the climate research discourse. We show that effective mitigation and adaptation are based on public-sphere actions and thus conclude that effective climate education should discuss those public actions if it is to be effective. Hence, we propose that climate education should incorporate political literacy to educate climate-literate citizens.

453 "Everyone Must Do something." - Primary School Students' Mental Models of Climate Change in the Context of Climate Ethics, Justice and Responsibility

Alexandria Krug

Leipzig University, Leipzig, Germany

Abstract

Climate change as a key problem and phenomenon of children's lifeworlds has the potential to evoke sustainable ways of living together. Therefore, especially in primary school, dealing with climate change is of importance for a critical-constructive educational process. In addition to the scientific aspects, transformative education requires ethical considerations to enable children to assess plural perspectives and make decisions. So, what do primary school students think about climate change? What are their ethical and justice-theoretical perspectives? What do they think about responsibility? This interdisciplinary dissertation investigates these questions in an explorative, qualitative- descriptive research design using problem-centred individual interviews, children's drawings and a structure-lay-map. The core interest concerns the mental models of climate change of primary school students and their evaluation of climate change in terms of climate ethics, justice theory and responsibility ethics. The data from the comprehensive pilot phase show a broad spectrum of ideas and evaluative perspectives. The elicitation of mental models enriches a transformative educational process to support learners in their reflexive critical reasoning process. This research contributes to holistic scientific literacy in the context of education in sustainable development.

455 Embedding a Transformative Dimension in Teaching/learning Climate Change

Giulia Tasquier

University of Bologna, Bologna, Italy

Abstract

Dealing with the threatening challenges that characterise our era requires the development of knowledge and skills to navigate uncertainty and complexity of science as part of everyday life. How can we support school students in transforming the base of knowledge and experiences to become agents of transformative change as current complex societal challenges require? We address this broader question through a study framed within [ANONYMISED] project, aimed at promoting new forms of scientific literacy and skills to empower students to become agents of change. The project conceives school science as involving learning and transformation across three spheres where both individuals and their institutional contexts change as participants gain agency. The study illustrates the approach and presents the analysis of an iteration.

484 "It's the Fear of Indoctrinating the Children": Statements of Prospective Primary School Teachers on Teaching Climate Change

Petra Breitenmoser

University of Zurich, Zurich, Zurich, Switzerland. Zurich University of Teacher Education, Zurich, Zurich, Switzerland

Abstract

Both career entry and teaching climate change are perceived by teachers as significant and complex and can be characterised by diverse demands and uncertainties. While research has focused both on career entry and teachers' knowledge and attitudes towards climate change, little attention has been paid to how these are jointly manifested in teachers' perceptions of career entry. Given that Education for Sustainable Development (ESD) is an important basis for sustainable development and that climate change is firmly anchored in the United Nations' Sustainable Development Goals (SDGs), a better understanding of these complex requirements is necessary not only for experienced primary school teachers, but already for those entering the profession. Based on a theory-based model for the development of pedagogical professionalism (Keller-Schneider et al., 2020) and by means of a qualitative content analysis as well as a concept mapping procedure (McLean & Link, 2022), this study shows how prospective teachers perceive job-related and topic-related requirements for teaching climate change against the background of individual resources. It can be shown that a lack of content knowledge and pedagogic content knowledge leads the teachers to either avoid the topic or reduce the perceived difficulty by focusing on individual, political-neutral actions such as recycling or saving energy without reflecting upon the underlying reasons. Impulses for the further development of teacher education are derived.

Parallel Session - 3.20 (WORKSHOP)

09:00 - 11:00 Tuesday, 29th August, 2023

1296 Turn Your Classroom into a Professional Lab with VERNIER

Yasemin Eren[1], Hüsnü Akalın[2], Can Akalın[2]

[1]Hacettepe University, Ankara, Turkey. [2]Renko Vernier, Ankara, Turkey

Abstract

Vernier recognizes that helping students meet standards is an important part of teaching today, and is committed to providing you with the most up-to-date information as standards change. We make it easy to apply technology in the classroom or lab with our educator-tested, ready-to-use experiments. Choose from over 1,000 experiments suitable for educators of all education levels to engage and inspire students of all ages. Moreover, free content compatible with curricula such as AP, IB, NGSS will be introduced. Students can wirelessly collect and

analyze sensor data from mobile devices, making each lab a collaborative and individual learning experience. LabQuest 2's wireless connectivity can be used to transfer sensor data to mobile devices or to view and control LabQuest from a computer or iPad.LabQuest Viewer software allows viewing and controlling LabQuest wirelessly from a computer or iPad. When used with a projector or smartboard, you can view any LabQuest screen for the entire classIn this workshop, an explanation will be given with examples on how VERNIER serves all components of the education system, teachers will be informed about how they can easily turn their classrooms into a professional laboratory, and an environment of learning by living will be provided by guiding them to try devices and use applications.

Parallel Session - 3.21 (WORKSHOP)

09:00 - 11:00 Tuesday, 29th August, 2023

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483 'Seeing the Invisible', a Workshop Showcasing an Approach to Explicitly Teach About the Nature of Scientific Models

Patrick Thill, Julia Woithe, Sascha Schmeling

CERN, Geneva, Switzerland

Abstract

Modern science often deals with invisible entities that cannot be observed directly and rely on sophisticated scientific models for their representation. In this context, we present an innovative enquiry-based learning activity that is designed to explicitly teach about the nature of scientific models. In the 'Seeing the Invisible' workshop, participants work in small groups and conduct a series of hands-on experiments to discover how scientists 'make the invisible visible', i.e. how do scientists set up experiments to measure properties that they cannot see with their own eyes? Subsequently, participants draw, test and revise models that are consistent with their observations. This activity is designed to be tailored according to age and enable diverse audiences as of five years old to engage with hands-on experiments that develop their understanding of the nature of scientific models. The audience partaking in this workshop will get an opportunity to explore their own scientific curiosity by rolling balls (e.g. ping pong balls) into a 'mystery box' and draw up their own models of the invisible internal structure based on their observations. This will be followed by a presentation of a small-scale evaluation study that demonstrated that students became more confident in their modelling skills and improve their understanding of scientific models after taking part in a version of this workshop. The session concludes with a discussion about parallels to other existing science education activities and with a reflection on how explicitly teaching about nature of science aspects links to modern science research contexts.

Parallel Session - 3.22 (WORKSHOP)

09:00 - 11:00 Tuesday, 29th August, 2023

749 Digital Teaching Scenarios on Advanced STEM Topics for Higher Education

Emily Michailidi[1], Eilish McLoughlin[2], Argyris Nipyrakis[3], Athanasia Kokolaki[1], Gunnar Friege[4], Priit Reiska[5], Dimitris Stavrou[1]

[1]University of Crete, Rethymno, Greece. [2]Dublin City University, Dublin, Ireland. [3]University of Groningen, Groningen, Netherlands. [4]Leibniz Universität Hannover, Hannover, Germany. [5]Tallinn University, Tallinn, Estonia

Abstract

This workshop, responding to the need for developing blended and distance learning environments for teaching advanced STEM topics in higher education, aims to familiarize participants with the educational use of various digital resources for science teaching in online and distance learning contexts and provide example of good practices regarding teaching and learning strategies that promote meaningful use of digital technologies for teaching STEM topics in blended or distance learning environments. Participants by rotation, in small groups and by using laptops and their mobile devices, will engage with the practical implementation of digital scenarios on Climate change, Water, and Ocean batteries & energy farms. By the end of the workshop, participants will engage in reflective discussions on distance learning approaches that provide quality learning experiences for prospective science teachers and on the affordances and limitations of integrating digital tools in teaching advanced STEM topics.

Parallel Session - 3.23 (WORKSHOP)

09:00 - 11:00 Tuesday, 29th August, 2023

665 Learning Everywhere: Breaking out of the Classroom and Linking Schools to the Community

Yvoni Pavlou[1], Tamar Fuhrmann[2]

[1]University of Cyprus, Nicosia, Cyprus. [2]Teachers College Columbia University, New York, USA

Abstract

Open Schooling (OS) is a promising framework for encouraging active interaction among schools and stakeholders such as parents, researchers, companies, and organizations for

addressing real-world problems. Nevertheless, enacting the OS framework with relevant and appropriate approaches in school contexts can be a perplexing process. The objectives of this workshop are two: to introduce the OS guidelines to the participants and to present two educational approaches to OS (i.e., the "Living Labs" and the "Make It Open" approaches), developed, implemented, and evaluated in the context of two EU-funded projects. The workshop comprises three segments: firstly, the participants are introduced to the OS framework and the two approaches, secondly, the participants in groups design a case-study scenario based on one of the approaches, which they will then present and, thirdly they share their viewpoints, their experiences with OS or similar methodologies, and discuss the potential and challenges of the OS framework. By the end of the workshop, the participants will develop a core understanding of the OS framework and gain experience with the two innovative educational approaches that can support introducing an OS culture at schools.

Parallel Session - 3.24 (WORKSHOP)

09:00 - 11:00 Tuesday, 29th August, 2023

170 Food is Our Mission: An Interdisciplinary Approach to Teaching Food Science in Schools

Keren Dalyot[1], Viktória Soós[2]

[1]Weizmann Institute, Rehovot, Israel. [2]Climate Smart Elephant, Budapest, Hungary

Abstract

Studies have demonstrated that interest in science is slowly decreasing as students advance in the school system. However, other studies have demonstrated that students have interest in nutrition and food, this interest can be leveraged to increase engagement with science education in general. In 2022, EIT FOOD under the scope of its Youth Mission program, bringing together a team of international education and science education experts, developed two interdisciplinary teachers' resources, connecting topics of healthy and sustainable food, food science and food education. In the pilot phase (Autumn 2022), the handbooks were tried and tested by teachers in 5 countries (Cyprus, Czech Republic, Israel, Hungary, Spain) with a reach of 97 teachers and 2123 students. The project was designed to demonstrate to the students both the global aspects of the food practices, such as sustainability of the food system and the local and personal aspects, such as seasonal produce. Therefore, promoting the complex understanding of food as a socio-scientific issue. By using this framework, we introduce to students the inter- and multidisciplinary aspects of food science (and science in general) and strive to make both the subject matter and skills gained relevant to their lives. We are proposing a workshop built on the Food Mission teachers' handbook for student aged 9-14 to demonstrate two of the most popular lesson plans in brief in a learning-by-doing manner and show how we include development of the following skills: critical thinking, science communication skills, group work and design thinking. We will also illustrate how we are linking

science topics to students' everyday life and experiences utilizing gamification elements. Participants will be encouraged to share their feedback on the handbook to continue improving its impact and use.

Parallel Session - 3.25 (WORKSHOP)

09:00 - 11:00 Tuesday, 29th August, 2023

1291 Engineering Design Coaching Tool for Sustainability and Ethically-Conscientious Education

Senay Purzer

Purdue University, West Lafayette, IN, USA

Abstract

The Engineering Design Coaching Tool is an instructional scaffold designed to promote student reasoning through discourse centred around the negotiation of design risk and benefits. This tool is particularly effective in promoting student agency and design reasoning through planned questioning. The session includes a presentation of two frameworks. The Honeycomb of Engineering Framework represents design practices connected through the central practice of negotiation. The Design Reasoning Quadrants Framework represents fluency across four types of reasoning necessary for effective design: experiential reasoning, trade-offs reasoning, first-principles reasoning, and futures reasoning. Centred on the negotiation of risks and benefits, a core practice of engineering, the framework allows classroom discourse and questioning necessary for sustainable and ethically-conscientious ways of creating, monitoring, managing, and improving technological systems.

Plenary Lecture - 2 by Mustafa Sözbilir

11:30 - 12:30 Tuesday, 29th August, 2023

Chair: Ingo Eilks

1305 How Has Science Education Research Evolved in the Last Two Decades?

Mustafa Sözbilir

Atatürk University, Erzurum, Turkey

Abstract

Science education has little history as a research field compared to the history of science. Although research in science education was a relatively new enterprise, it is evolving since the beginning of the twentieth century. The development of research in science education is strongly affected by curriculum developments. Therefore, research studies carried out during the 1960s were often linked to curriculum development work Many other studies were focused on difficulties in teaching new curriculum issues and the use of new teaching strategies. However, in the 1980s reform, new perspectives on teaching and learning caused a shift in the interest of many researchers towards studies of students' alternative conceptions and ways of reasoning. The science education literature has been dominated by research findings concerned with children's understanding and learning of scientific phenomena in the last couple of decades of the twentieth century. In line with this interest, more and more studies focused on students' learning processes in terms of conceptual change. There was also a growth in studies of the social and cultural dimensions of knowledge acquirement, for instance, by investigating the discourses between teachers and students in the classroom. Other trends were the growth in interest in studies of laboratory work, especially (open) inquiry, the implementation and use of problem-solving strategies etc. This talk will start with a short account of science education research development and its evaluation as a field and then focus on the developments in the last two decades. Particularly, results of a bibliometric analysis study which is based on research papers published around the world will be shared to show how Europe contributed to science education together with Türkiye's contribution to science education research literature.

Parallel Session - 4.1 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Ceren Baser-Kanbak

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193 Metaconceptual Teaching about Intuitive Conceptions: Influence on Cognitive Load and Self-Efficacy

Tim Hartelt, Helge Martens

University of Kassel, Kassel, Germany

Abstract

Metaconceptual teaching can help students become aware of their own intuitive conceptions and regulate them in scientific contexts where they are not appropriate. Especially two metaconceptual instructional approaches have been found to enhance students' conceptual understanding: (a) self-assessing one's own conceptions and (b) acquiring conditional metaconceptual knowledge about why and in which contexts specific conceptions are appropriate or not. However, it is unclear how these metaconceptual approaches influence students' self-efficacy and cognitive load. Yet, it is important to investigate to what extent metaconceptual activities acquire additional cognitive resources and if making students aware of their intuitive conceptions lowers or increases their confidence. Thus, we conducted an experimental intervention study with N = 602 secondary school students by systematically varying both instructional approaches. We found a positive effect of the intervention on students' self-efficacy in all groups, even the control groups. Despite a lacking positive effect of metaconceptual teaching on students' self-efficacy in comparison to the control groups, this finding can be interpreted as promising because making students aware of their intuitive conceptions could have also decreased students' confidence. Students that self-assessed their own conceptions reported a higher cognitive load than students in the control groups, while the intervention on conditional metaconceptual knowledge had no effect. However, students who worked on both intervention materials reported the lowest cognitive load. Further, students' self-reported metaconceptual awareness before the intervention correlated negatively with their cognitive load during the intervention, meaning that students who regularly reflect on their conceptions had a lower cognitive load. While the latter results may imply that incorporating metaconceptual activities regularly in class may reduce cognitive load related to metaconceptual thinking, potential adjustments of this instructional approach to reduce cognitive load must be discussed to further increase the effect on students' conceptual understanding.

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929 The Cognitive Side of Conceptual Change in the Learning of Successive Theories

Giacomo Zuccarini, Marisa Michelini, Lorenzo Santi

University of Udine, Udine, Italy

Abstract

With modern developments in science and technology, the social significance of learning successive theories is steadily increasing. Many researchers examine the teaching of these subjects in the framework of conceptual change, which was developed to account for the acquisition of scientific knowledge by introductory students. We propose a model specifically designed for the case at hand, describing the identification of two cognitive signatures of the initial state of the learner, as well as of methods and visualization tools for exploring their dynamics in theory change and related challenges. The model highlights the complementarity of coherence and fragmentation views, suggesting strategies to address knowledge revision and overcome fragmentation. We report data on their effectiveness in a course of quantum mechanics for secondary school students.

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412 Building of an Osmosis Model Using Descriptive Knowledge Generated by an Instructional Sequence at Pre-Service School Teachers.

Luis Delgado-Mayoral, Manuela Gonzalez-Herrera, Maria Martinez-Chico, Rut Jimenez-Liso

University of Almeria, Almeria, Spain

Abstract

The difficulties involved in teaching osmotic processes at all levels of education have been widely studied, but the solutions they propose are very general. We present an instructional sequence of inquiry and modelling at Pre-Service School Teachers, which allows students to generate sufficient descriptive knowledge to build an initial osmosis model. To do this, we propose as an initial question an environmental problem caused by desalination plants on the marine ecosystem. This generates contextualization and importance in what they study, and promotes the search for knowledge about osmosis. To measure the effectiveness of the sequence in the generation of the osmosis model, we will use a qualitative-interpretative methodology and its applicability to other contexts where osmotic processes are fundamental.

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182 Pre-Service Teachers' Earmarks on the Aspects of the Climate Change-Specific TPACK

Ceren Baser-Kanbak, Mine Tanrisevdi, Serife Sevinc

Middle East Technical University, Ankara, Turkey

Abstract

With inclusion of technology in education, pedagogical content knowledge is extended as technological pedagogical content knowledge (TPACK) framework. Yet, considering the scarce literature on content-specific TPACK, this study aims to understand what aspects of climate change-specific TPACK identified by pre-service science teachers. Using qualitative single-embedded case study design, data were collected from four pre-service teachers' through semi-structured interviews. Interviews revealed that senior PSTs' highlighted more earmarks for climate change related TPACK than juniors. Implications of need of comprehensive courses including technology, pedagogy, content and practice can be highlighted for the teacher education programs.

Parallel Session - 4.2 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Yasemin Eren

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711 Redesigning an Action Research Module on Sustainable Communities with Pre-Service Teachers

Tristan Orbeta

University of the Philippines, Diliman, Quezon City, Metro Manila, Philippines

Abstract

Positioning science at the core of the knowledge component of Education for Sustainable Development (ESD) allows students to not only learn scientific concepts but also aid in the realisation of a sustainable future in the Anthropocene. The achievement of the sustainable development goals (SDGs) is conceivable if the ESD priority action areas are addressed, one of which is building the capacity of educators. Pre-service teachers' (PSTs) earliest training milieu is their own formal education. Alongside learning content and pedagogy, this is also an opportune time for them to apply their knowledge and improve their competence. In this study, a prototype of an action research module on sustainable communities was field tested among a group of undergraduate students taking the Bachelor of Secondary Education program in a Philippine university. The participants, as module users, first engaged with the Science for Global Goals curriculum developed by the Smithsonian Science Education Centre in the United States. Post-exposure to the materials, the participants, using the lens of prospective teachers, critiqued the module. The evaluations were used to inform the succeeding versions of the educational materials. Using the case study approach, the aim was to examine and describe patterns across pre-service teachers' critiques of the action research module. Throughout the semester of implementation, case data were collected and analysed using the emerging code perspective. Analyses indicate that the critique remarks were predominantly opportunities for

module improvement. Findings suggest that target competencies, content and element interactivity, learning processes, and authentic assessments, among others, form the conceptual infrastructure of developing a tool that pre-service teachers or educators at large may adopt when evaluating learning modules.

1070 Enhancing Sustainable Thinking Through 3D-Design

Anthoula Maidou[1], Hariton Polatoglou[2]

[1]2nd Model Junior High School of Thessaloniki, Thessaloniki, Greece. [2]Aristotle University of Thessaloniki, Thessaloniki, Greece

Abstract

Many contemporary problems, such as the climate crisis, pandemics, wars, economic recessions, etc., are problems of sustainable development. To overcome these problems people, need to change their mindset on a global scale and collaborate to promote the sustainability goals. To achieve this, Education for Sustainable Development (ESD) should be introduced to all educational levels. 3D-design and printing techniques are a growing field used in many manufacturing processes. 3D-design and printing techniques have only very recently been introduced in the educational process. During the school year 2021-22 we organized a yearlong curriculum using 3D-design in a lower secondary school with the aim to introduce students to 3D-design as a means of communication and expression of their ideas for ESD, design thinking, and the cultivation of the 21st century skills. The educational design consisted of short introductory videos and was followed by hands-on activities in order to introduce the students to 3D-design, so that they could express their ideas without difficulties. A questionnaire was used before and at the end of the curriculum to gain an insight about students' knowledge and perceptions of 3D-design. From the analysis of the questionnaires and the students' designs, it appears that 3D-design was a suitable means to familiarize students with the concepts of sustainability, solving real world problems, design thinking, and the development of 21st century skills.

1294 Sustainability of Aviation and Space Subject Area in Science Education

Yasemin Eren, Sinan Erten

Hacettepe University, Ankara, Ankara, Turkey

Abstract

In this study, the main aviation and space education and teaching practices around the world are examined and compared with the efforts in Turkey. The aim is to elaborate on the concepts of aviation and space in the education of K12 level students, and to present thoughts and suggestions to train the workforce needed by the national aviation and space industry. The development of education and teaching processes in this field is also researched while examining the aviation and space studies of countries, and what needs to be done in Turkey's aviation and space policies and educational practices is explored. The document analysis

method, one of the qualitative research methods, was used in the study. In this study, the approaches of countries providing aviation and space education at the K12 level in the near future, and the current situation for understanding the importance of the subject in Turkey, were examined using purposive sampling methods, including easily accessible situation sampling. The choice of this method is based on the idea of bringing speed and practicality to the research. It was determined that when the general approach of the United States, Canada, the United Kingdom, and Australia to this field and their studies are examined, Turkey has relatively lagged behind in its efforts in this area. Ultimately, educating children about aerospace is important because it can inspire critical thinking, creativity, global citizenship, and environmental awareness while also inspiring them to explore new ideas and pursue careers in STEM.

Parallel Session - 4.3 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Emine Adadan

1037 Examining First-Year College Students' Understanding of Vapor Pressure: The Influence of Competency in the Particle Nature of Matter

Emine Adadan[1], Meltem İşcan[2]

[1]Bogazici University, Istanbul, Turkey. [2]ITU Gelistirme Vakfi Okullari Özel Ekrem Elginkan Lisesi, Istanbul, Turkey

Abstract

This mixed method study mainly explored the conceptual understanding of vapor pressure held by students with a high understanding of particulate nature of matter (PNM) and students with a low understanding of PNM. A total of 48 first-year college students who were enrolled in General Chemistry course participated in the study. Data were collected through a diagnostic test about the PNM and semi-structured interviews on vapor pressure. Data obtained from diagnostic tests and interviews were coded and analyzed by using quantitative and qualitative methods. The findings showed a statistically significant difference between the students with a high understanding of PNM and the students with a low understanding of PNM in terms of understanding the different aspects of vapor pressure. Students with a high understanding of PNM were more likely to develop a scientific understanding about the different aspects of vapor pressure compared to the students with a low understanding of PNM.

1098 A Thematic Unit on Air Pollution for the Teaching of Inorganic Compounds Based on Active Methodologies

Daniele Raupp, José Gregório, Gislaine Penha Rossetto

Federal University of Rio Grande do Sul, Porto Alegre, RS, Brazil

Abstract

According to the World Health Organization, air pollution is one of the greatest environmental risks to human health. Several gaseous inorganic pollutants enter the atmosphere as the result of human activities. Significantly increased atmospheric CO2 levels causes acceleratedglobal warming and associated impacts. Globally, atmospheric emissions of carbon dioxide, sulphur oxides and nitrogen oxides are of the order of one to several hundred million tons per year. In that regard, the discussion of environmental issues in classrooms is necessary since these problems are directly linked to human actions and choices. With the objective of developing a Thematic Unit (TU) on Environmental Chemistry, focusing on the atmospheric pollution by inorganic gases and its direct relationship with the High School chemistry contents, we present herein a proposal, based on active methodologies, performing experiments carried out with easily available materials and having as a theoretical contribution the Ausubel theory of meaningful learning. It was developed in the National Master's Professional Program in Chemistry – PROFQUI of the Federal University of Rio Grande do Sul, Brazil and it was applied to 14 students from a public High School in southern Brazil. The data collected was analysed from the perspective of Bardin's content analysis. The results show that the teaching was favoured by the approach of the thematic and by the teaching methodology, allowing the discussion and reflection of environmental aspects that are barely considered in the classroom. Through the proposed activities, students were able to identify and reflect on the causes and consequences of air pollution and the responsibility we have in preserving the environment. In addition to establishing an intrinsic relationship between the chemical content and the students' prior knowledge, the TU promote the student's autonomy and greater engagement, favouring motivation in the classes. Such factors can contribute to a potentially significant learning.

1244 A Qualitative Model of the Evaporation Process for Science Education

Paulo Vitor Teodoro[1], Paulo Salles[2], Ricardo Gauche[2]

[1]Federal University of Uberlândia, Ituiutaba, Minas Gerais, Brazil. [2]University of Brasília, Brasília, Distrito Federal, Brazil

Abstract

It is important understanding how students learn chemical concepts, including it has been a great concern for researchers of chemical/science education. This community is making efforts to identify the most important misunderstandings and develop strategies to overcome conceptual problems. Qualitative Reasoning (QR) has great potential for building conceptual models that can be useful for chemical education. QR is an area of Artificial Intelligence that

uses the symbolic reasoning to represent mathematical functions without numbers and with explicitly modeled relationships of causality. This paper describes a qualitative model of the evaporation process, to support understanding of interactions between change of the physical state of matter and energy exchanges. The model support explanations about changes in the physical state of the matter from the kinetic energy point of view. Finally, we discuss the potential of QR articulate models for science education.

1299 Teaching for Conceptual Understanding of Electrolytic Cells: The Three Levels of Explanation

Brighton Mudadigwa

University of Pretoria, Pretoria, Gauteng, South Africa

Abstract

An explanatory case study inquiry was undertaken to investigate five teachers, teaching electrolytic cells and their fundamental concepts from grades 10 to 12. The in-service teachers from schools of different backgrounds were observed teaching a series of three lessons each. An approach on scales of representations by Scott and the triangle of levels of thought by Johnstone were used to analyse teachers' use of macroscopic, sub-microscopic and symbolic levels in the teaching and learning process. The sub-microscopic level was superficially used by the participants, which compromised conceptual understanding of scientific concepts. A continuum in the capabilities and use of the three levels of explanations by teachers was realised. Hence, there is a need to professionally develop in-service teachers with the pedagogical knowledge that fosters conceptual understanding.

Parallel Session - 4.4 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Ane Portillo-Blanco

1063 Middle School Female Students' Perceptions of Scientists (Vs. Fashion Models) as Described in Their Stories and Drawings

Banu Avşar Erümit, Fazilet Topçu, Rümeysa Koç, Ömür Gül, Burhan Erdem, Feray Kaya, Tuba Açıkgöz

Recep Tayyip Erdoğan University, Rize, Turkey

Abstract

The Draw-A-Scientist Test (DAST) is a well-known instrument used by many science educators worldwide to understand students' conceptions of scientists. Since Chamber's study, numerous studies have examined people's perceptions of scientists and found stereotypes in students'

drawings. To broaden the field of study, we have developed new research instruments that include students' drawings and stories of a scientist and a fashion model based on a scenario we have provided. The participants were 149 female middle school students from grades 5, 6, 7, and 8. Students' stories and drawings of scientists and models provided essential findings. Drawing scientists and fashion models and developing stories about their lives provided detailed information about students' perceptions of scientists.

124 Evaluation of a Model-Based Inquiry Teaching/Learning Sequence on Plant Nutrition

Oier Pedrera[1], Oihana Barrutia[1], José Ramón Díez[2]

[1]University of the Basque Country (UPV/EHU), Donostia-San Sebastián, Spain. [2]University of the Basque Country (UPV/EHU), Leioa, Spain

Abstract

The Scientific Model of Plant Nutrition (SMPN) is arguably one of the most relevant and challenging Biology models. Several studies have attempted to design teaching/learning interventions aimed to improve students' conceptualisations about the topic with limited success. This study reports the results of a Model-Based Inquiry (MBI) Teaching/Learning Sequence (TLS) designed within the framework of Design-Based Research (DBR). The goal is to facilitate 16-17 aged students (1st year of Spanish Baccalaureate) the construction of mental models close to the scientific consensus on plant nutrition. The research follows a pre-post quasi-experimental design with control group in which 95 students have participated as the experimental group (MBI TLS) and 39 as the control one. According to the results of the phenomenographic analysis conducted with the pre-post tests, the MBI TLS is successful in promoting and improving students' ideas about two of the most demanding aspects of the model, photosynthesis and respiration (i.e. how do plants obtain matter and energy). However, facets such as the ecosystemic dimension or the temporalisation of the abovementioned processes do not show significant differences between the cohort groups. Hence, the results suggest that the TLS is promising, but it should be refined and reevaluated considering these outcomes in order to promote the construction of meaningful and scientifically accurate models which deem all the aspects.

1255 Develoment and Use of an Observation Manual for Science Teaching

Mai Lill Suhr[1], Solveig Karlsen[2], Magdalena Kersting[3], Marit Kjærnsli[4], Magne Olufsen[2], Johannes Sæleset[5], Marianne Ødegaard[4]

[1]Inland Norway University, Hamar, Norway. [2]The Arctic University of Norway, Tromsø, Norway. [3]University of Copenhagen, Copenhagen, Denmark. [4]University of Oslo, Oslo, Norway. [5]NLA University College, Bergen, Norway

Abstract

Science teaching is a complex process to observe. Analysing video data from science classrooms using an observation manual designed for science teaching data may capture rich and detailed descriptions of instructional practices. In the LISSI-project, we developed a science teaching observation manual to analyse more than 80 lessons including 20 teachers in Norway through a process based on existing observation manuals, literature and studying the video data. Applying the manual provided a rich data material describing many details of the different lessons, but this type of analysis has its limitations, as there are elements of instruction that it is not possible to capture and provide information about student learning.

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760 Enjoying the Sun in a Healthy Way: Implementation and Evaluation of a STEAM Project for High School

Ane Portillo-Blanco[1], Kristina Zuza[1], Jenaro Guisasola[2]

[1]UPV/EHU, Donostia, Gipuzkoa, Spain. [2]College of Dual Engineering. Institute of Machine Tools Campus (IMH), Elgoibar, Gipuzkoa, Spain

Abstract

This paper presents the evaluation of a STEAM implementation with secondary school students. A STEAM project is one that integrates content, beliefs, and skills from at least two disciplines that constitute the acronym and in this study the topic of "Sunbathing" has been used as a problem to unite the disciplines of physics and biology in the same context. After its implementation with 23 students, three evaluation instruments were used to analyse the impact on both knowledge acquisition and scientific procedures of the participants. These instruments are based on pre-post comparisons analysed through phenomenography and on experimental reports analysed through evaluation rubrics. The results show an increase in conceptual knowledge and in the ability to translate theory into practice through real cases, as well as a good performance on the scientific procedures when using the protocol designed for the project.

Parallel Session - 4.5 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Anne Laius

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5 A Digital Game-Based Science Activity for Children: Stop Climate Change

Orkun Kocak[1], Sahin Idin[2]

[1]TED University, Ankara, Turkey. [2]TUBITAK, Ankara, Turkey

Abstract

Climate change and its effect are impacting our world more and more with each passing day. For this reason, we must ensure that our children, as the society of the future, grow up as individuals with high environmental awareness, being aware of climate change and its effects. The aim of this study is to inform students about the subject of climate change and educate them as individuals with climate change literacy. In this context, a digital game about climate change and its effects was developed for primary and secondary school students. It was determined that the students enjoy this game, called Stop Climate Change; they had fun and simultaneously learned about concepts related to climate change.

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225 Introducing the Control of Variables Strategy to Preschool Student Teachers with the Assistance of an Augmented Pedagogical Agent

Angelos Sofianidis[1], Silvestra Sakellariou[2], Anastasios Zoupidis[3], Euripides Hatzikraniotis[2]

[1]University of Western Macedonia, Florina, Greece. [2]Aristotle University of Thessaloniki, Thessaloniki, Greece. [3]Democritus University of Thrace, Alexandroupoli, Greece

Abstract

During the last decade, Augmented Reality has contributed to the teaching of challenging topics of Science Education in several ways. Our paper focuses on the Control of Variables Strategy (CVS) - an essential sub-phase of inquiry and a challenging topic for students of all ages. According to the existing literature, combining explicit instruction with implicit learning through experimentation is the most effective approach in teaching and learning the CVS method. To enhance students' autonomy and increase their motivation, an Augmented Pedagogical Agent called Nefeli was designed to assist preschool teacher students to implement CVS when facing problems with two independent variables in inquiry-based activities. The aim of the present pilot study was to assess students' perceptions regarding their experience and Nefeli and draw an initial evaluation of the learning outcomes. The results indicate that most students found the use of Nefeli very useful and interesting and believe that Nefeli helped them understand how to apply CVS principles. Students also highlighted the positive characteristics and some issues of Nefeli for revision. Despite these issues, the learning outcomes seem very promising since the majority of the students successfully applied CVS to the given problems after working with Nefeli. These findings and the very positive stance of students on the Augmented Pedagogical Agent indicate a promising research agenda concerning the teaching and learning of CVS using the affordances of AR.

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467 Introduction of a Digital "SpinDrops-Learning Environment" for ^{1}H-NMR-Spectroscopy

Dominik Diermann, Dennis Huber, Steffen Glaser, Jenna Koenen

Technical University of Munich, Munich, Bavaria, Germany

Abstract

NMR (nuclear magnetic resonance) spectroscopy seems not only to be difficult for students to understand but also for lecturers to teach adequately (Connor, 2021). Therefore, we introduce a digital learning environment aiming to address students' learning difficulties to facilitate understanding of important ^{1}H-NMR background knowledge. The *SpinDrops-Learning-Environment* (SDLE) covers the concepts of the precession movement of a spin, the chemical shift and the concept of spin-spin-coupling and its effects on a ^{1}H-NMR-spectrum. To do so, the SDLE provides different open tasks accompanied by guided explanations. The software offers hints and feedback presented by a pedagogical assistant, interactive visualizations, and a realistic and dynamic simulated NMR-spectrum, which will update directly with every interactive parameter-change the user applies while working on a specific task. The SDLE therefore, combines suitable methods or digital tools with a yet, unanswered problem-field. The SDLE was developed and investigated empirically. These investigation yield insights into the ways students work with the SDLE and its different features. The data so far suggests that students benefit from learning with the SDLE in general. Their NMR-related interest, self-efficacy and their estimation on their NMR-related knowledge and skills increase significantly. Further information on the way students work and learn with the SDLE will be gained by further evaluating and interpreting our (procedural) data.

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478 The QCAmap Analysis of the Use of Digital Technology and Materials in Teaching Science

Anne Laius, Getriin Orgusaar

University of Tartu, Tartu, Estonia

Abstract

Digital competence is defined as the use of digital technology in learning and teaching, as described in the national curriculum for basic schools. With the development of digital technology, teachers also need to adapt their teaching by using digital tools and materials in their teaching. The aim of this Master's thesis is to study the use of digital technology solutions in science lessons: what tools are used and how much are used in science lessons, what are the obstacles and differences in the use of digital distance and contact learning tools. A questionnaire was developed for the study, which was answered by 70 science teachers. The data was analysed with the qualitative data analysis software QCAmap, and it was exported into MS Excel, where further analysis and comparison was carried out. The results showed that science teachers mainly use computers (desktops, laptops and tablets) in their work. The biggest obstacles to using digital tools are the lack of subject content and foreign language materials, as well as outdated data, difficult-to-learn materials and non-compliance with the curriculum. The use of digital tools increased significantly in distance learning.

Parallel Session - 4.6 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Martina Kekule

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540 Learning Pathway Model (LPM): A Tool to Analyze the Level of Abstraction on Scientific Ideas

João Roberto Ratis Tenório da Silva

Federal University of Pernambuco, Caruaru, Pernambuco, Brazil

Abstract

The construction of new meanings characterizes the learning process, that is, the emergence of novelty. This process grows out of a movement between concrete and abstract ideas. At the same time, students think about issues posed in a learning situation, as in Vygotsky's idea of spontaneous and scientific concepts. On the other hand, we can also interpret this phenomenon by using the notion of schematization and pleromatization from Valsiner's theoretical approach, in which students can "transit" between certain kinds of semiotic mediation. In this sense, this paper aims to present an analytical tool called Learning Pathway Model (LPM) to investigate how students achieve different levels of abstraction during the meaning-making process. This tool proposes three different levels of abstraction representing an approach to or a withdrawal from the scientific view of the concept. To illustrate these ideas, we examined a case in which four students organized into two couples tried to answer a question about chemical substances after attending a video lesson. The outcomes showed us that during the dialogue, students ratiocinated about the concept of substance transiting through concrete and abstract ideas and achieved different levels of abstraction being able to externalize definitions related to the concept of substance.

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681 A Comparative Study of High School Students' Sense of Belonging to Physics Course and Their Epistemologies Related to Physics Due to Gender, School Type, and Grade Level

Kübra Özmen[1], Merve Düriye Biçmen Şenol[2]

[1]Başkent University, Ankara, Turkey. [2]Küçükçekmece Anadolu Lisesi, İstanbul, Turkey

Abstract

Personal epistemology refers to an individual's beliefs about the nature of knowledge and the processes by which it is acquired. Studies have shown that students who feel a strong sense of belonging in a physics course are more likely to hold more sophisticated beliefs about the nature of physics knowledge and the processes of scientific inquiry. This study aimed to compare high school students' sense of belonging to physics course and their epistemological beliefs related to physics due to school type (Anatolian high school [AHS] vs. science high

school [SHS]), grade level, and gender. The study adopted a causal-comparative research design. Convenience sampling was used to select two high schools in Küçükçekmece province of Istanbul. In total, 555 students (female: 330, male: 225) participated in the study, including ninth to eleventh-grade levels. Non-parametric statistical tests, Mann Whitney U and Kruskal Wallis H were conducted to compare groups due to the violation of the normality assumption. The results showed that AHS and SHS students did not differ regarding the sense of belonging to the physics course and epistemological beliefs related to physics. However, SHS students have more sophisticated beliefs than AHS students regarding the subdimensions of "justification of knowing", "changeability of knowledge", and "source of knowledge". Eleventh-grade students were differentiated only regarding beliefs of "justification of knowing" compared to ninth and tenth-graders. Students' sense of belonging did not differ according to grade level. However, male students have a stronger sense of belonging to physics courses than female students. Female students have a more sophisticated epistemological belief in the structure of the knowledge dimension. In conclusion, students do not differ much due to school type despite different educational aims. In some specific dimensions of personal epistemology like justification, SHS students are more likely to use reasoning tools than AHS students.

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716 "If You Really, Really, Want to Know It You Have to Touch It" – Researching the Role of Touch in Children's Science Education

Laura Colucci-Gray, Jonathan Hancock, Andrew Manches

Moray House School of Education and Sport, University of Edinburgh, Edinburgh, United Kingdom

Abstract

Whilst the sense of touch, or haptics, is commonly recognised as a crucial means of communication, social interaction, and sense-making, vital for exploring the world around us, the mechanisms behind its role in learning have been less clear, and less explored compared to written-visual and verbal-auditory senses (Novak & Schwan, 2021; Minogue & Jones, 2006). This likely reflects the dominance of traditional cognitive paradigms in science education, which can prioritise notions of amodal abstraction. Yet increasing evidence for the embodied nature of cognition has indicated the importance of the body, and sensory and movement experiences, in learning (Nathan, 2022) and prompts us to re-evaluate, and develop new approaches for understanding, the significance of touch. To address this challenge, this paper draws on a study involving 93 children aged 6-9 across three primary schools, based in the UK. Fieldnotes, video and audio recordings were collected during observations of children interacting indoors with a series of physical objects and over the course of four outdoor workshops in the school grounds. Analysis of data source revealed the complex ways in which younger learners experience, explore, and place value in touch, their awareness and readiness to employ touch for science learning, and the ways in which haptic experiences supported learning through action, verbal communication, and gesture. Findings point to a wide array of dimensions of scientific inquiry mediated by touch and contribute to widening awareness of

the value of sensorial inquiry in science education.

881 Students' Interaction with Pictures in Physics Texbooks Observed by the Eye-tracking Method

Martina Kekule, Alzbeta Krejci

Charles University, Prague, Czech Republic

Abstract

We used the eye-tracking method to observe students' strategies when they read a text from a physics textbook supplemented by both pictures and questions. In the paper, we focused on students' interaction with pictures which can poses different amount of information; information, ranging from purely decorative pictures (no information) to being important for understanding the text (according to Pozzer, Roth (2003)). We observed different attention allocation to pictures in different categories and our preliminary results are in agreement with our expectation: students spent less time on the more decorative pictures, several of them have not even visited the only decorative picture at all.

Parallel Session - 4.7 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Chris Reid

472 Sound as Both Concept and Perception: The Case of Timbre and Its Shared Representations

Ernani Rodrigues, Thaís Borges

Federal University of Espírito Santo, Vitória, Espírito Santo, Brazil

Abstract

Human perception of natural phenomena plays an important role in in building understandings about the functioning of nature. The fact that some themes in Physics are marked by perceptual aspects calls into question both radical objectivity and individuality in the construction of knowledge. In this work, we explore nuances of sound timbre in emerging complex networks from socially shared representations in a group of high school students in Brazil. Results show representations more anchored in sound emitters than sound receivers, corroborating existing literature on representations about timbre. It raises the importance of bringing the perceptive and aesthetic characteristics of sound to elementary school physics classes, not as something marginal, but as a way of producing social agreements about the nature of sound.

567 Sensemaking Practices and Its Relationship to the Change in Teacher Identity: Supporting Elementary Students in Science Sensemaking

Selin Akgün, Joseph Krajcik

Michigan State University, East Lansing, Michigan, USA

Abstract

Fostering relevant, meaningful, and equitable science learning environments where sensemaking occurs has become a critical objective for the science teaching community. We discuss sensemaking as an active, reciprocal, social, and cultural process in which students not only reflect on what happened but figure out why and how phenomena happen, considering their backgrounds and experiences. We explore elementary students' science sensemaking experiences by examining six core sensemaking practices. These practices become essential to support students' learning and help teachers develop science teaching repertoires and professional identities. Using a longitudinal case study, we investigate a 3rd-grade elementary teacher's implementation of these sensemaking practices and how her implementation trajectory and identity change over time. These practices disrupt traditional classroom structures, help teachers form professional science teacher identities, and support equitable and meaningful sensemaking experiences for students.

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514 Perspective-Taking as an Approach to Increase Students' Moral Sensitivity

Elianne Gerrits[1], Annlies Pieterman[1], Annelien Bredenoord[2], Marc van Mil[1]

[1]University Medical Center Utrecht, Utrecht, Netherlands. [2]Erasmus University Rotterdam, Rotterdam, Netherlands

Abstract

Ethics education for scientists generally focuses on teaching students the competencies necessary for making ethical decisions. A competency often described in this context is moral sensitivity, the ability to recognize which moral aspects are relevant in a situation. We argue that the development of moral sensitivity can be fostered through teaching strategies that tap into students' moral imagination. Moral imagination can be described as the use of products of our imagination to look at a situation from a moral point of view. One of the merits of moral imagination is that it can help students to explore the perspectives of others. When students broaden their interpretation of a situation by including the perspectives of others, they can recognize additional moral aspects that are relevant in a situation and, in this way, increase their moral sensitivity. In our contribution we'll describe the results of an empirical study in which we analyzed the effect of a perspective-taking exercise on moral sensitivity using the previously validated Test for Ethical Sensitivity in Science (TESS). Quantitative analysis of our results suggests that students who recognize more stakeholders in a scenario show moderately higher levels of moral sensitivity as measured by the TESS. Qualitative analysis indicates that students who score higher in the TESS more often weigh the costs and benefits for multiple stakeholders. Students that score lower more often focused on the scientific process behind the innovation

and focus less on societal implication. With this work, we aim to inspire teachers to encourage their students to take the perspective of others when evaluating the moral aspects of a situation. When doing this, students should be stimulated to take the perspective of all relevant stakeholders involved and focus not only on the scientific process but also the societal implication of new biomedical innovations.

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527 What Role Does Curiosity Play in the Science Classroom? Report on a Pilot Study

Chris Reid

King's College, London, United Kingdom

Abstract

Children's curiosity has been a focus of several international policy initiatives (e.g., Department of Education (Australia), 2015; Department of Education (Ireland), 2019). Researchers have claimed that there are numerous benefits associated with being curious, including increases in enquiry behaviours, motivation and interest in school subjects (Chin and Osborne, 2008; Wu et al., 2018). Concerns have been raised in the literature that children's curiosity, as well as its expression within the classroom, undergoes a rapid decline as children age (e.g., Engel, 2015). Very little is known, though, about what makes children curious in the science classroom (Jirout and Klahr, 2012; Lindholm, 2018). To help rectify this deficit, I will report on a pilot study I am conducting into students' curiosity about science learning at secondary school. It will take place in an English comprehensive school using a class of 30 year 7 (age 11-12) students, together with their two science teachers. Five of the students will be selected for a more in-depth examination of their curiosity. My pilot study will compare students' and teachers' views of curiosity and its expression in the classroom to definitions encountered within the literature to better understand the degree to which the academic definition can be used to guide research within the classroom. The experience sampling method, designed to assess the correspondence of various psychological constructs with activities that participants are engaged in, will give an indication of what happens in the classroom to induce curiosity in students. Interviews with students will allow for deeper exploration into students' perceptions of the reasons behind this relationship between curiosity induction and classroom activity.

Parallel Session - 4.8 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Georgios Villias

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937 A Course of Material Design in Science Teacher Education: Designing Science Teaching Materials With Design Thinking

İlknur Güven, Merve Sak Yalmanoğlu

Marmara University, Istanbul, Turkey

Abstract

Design thinking is a non-linear, iterative process that seeks to understand users, challenge assumptions, redefine problems, and create innovative solutions for prototyping and testing. In this study, we focused on the pre-service teachers' designing science teaching materials with the design-thinking approach. Design thinking allows for flexibility and adaptability in planning processes, has already been embraced as a strategy for educational reform efforts. This study is about the application of a course based on Design Thinking during one semester at a public university in Istanbul in Science Teaching program with the pre-service science teachers taking the online Material Design in Science Education course in their third year in the spring semester of 2020-2021 education year. In this context, the aim of this study, was to make pre-service science teachers to learn about design thinking and to use it for problem-solving activities. They designed and built science teaching materials with design thinking approach by determining the misconceptions of the middle school students. They met with the middle school students and tried to solve their problems with the science teaching materials they built for them. The course is explained in detail.

1220 The 3D Material Development Process of Physics, Chemistry and Biology Teachers

Ayşegül Aslan[1], Ümmü Gülsüm Durukan[2], Demet Batman[1]

[1]Trabzon University, Trabzon, Turkey. [2]Giresun University, Giresun, Turkey

Abstract

It is well known that students struggle to perceive and visualize abstract concepts in science courses, and teachers struggle to provide course materials that they can use to embody these concepts. This concept was developed and is now being implemented to assist both students and teachers in meeting these needs. Within the scope of this idea, physics, chemistry, and biology teachers selected on a voluntary basis and working at the high school level in a province chosen as a sample are trained to design 3D materials and print these using 3D printers. Based on the Design Thinking Model (DTM), teachers are trained on 3D printers and various software that can be used in the design process to print out on these printers. During this process, each teacher was also asked to indicate the subjects that students had difficulty understanding and embodying in the teaching process using forms created by considering the units and subjects according to the four grades at the high school level within the scope of their fields and curriculum. In addition, the researchers kept field notes for the project process. The information gathered from the forms and field notes was analyzed using descriptive statistics. The subjects of "Energy and Motion, Torque, Simple Machines, Magnetism-Electromagnetic Induction" by

physics teachers, "Atomic Models, Electrolysis, Hybridization-Molecule Geometries" by chemistry teachers, and "Cell, Heredity and Biological Diversity, Controlling and Regulatory System, Sense Organs" by biology teachers were determined as a result of the analysis of the data, with the intersection of the subjects that students have difficulty comprehending and that teachers require material support. Following this application, research on the 3D material development process for the three concepts chosen from among these subjects began. The DTM's needs identification and idea generation stages are currently complete, and prototype creation studies are ongoing.

1233 Investigating the Effect of Systems Thinking Based 7th Grade Science Activities on Academic Achievement and Systems Thinking Skills

Onurhan Güven, Haluk Özmen

Trabzon University, Trabzon, Turkey

Abstract

This study aims to evaluate the effectiveness of systems-based science activities on the academic achievement and systems thinking skills of 7th grade students in a public school. The study was designed as a pre-test post-test quasi-experimental study. The activities were developed based on the objectives of the 7th grade force and energy unit and the literature on systems thinking. The data was collected using an academic achievement test, concept maps, and word association tests. The results of the study were analyzed using SPSS, and non-parametric tests (Mann-Whitney and Wilcoxon) were used to compare the groups and pre and post-test results. The findings for the achievement test indicate that the activities are useful to make students more successful. The findings for the concept map and the word association test will be provided later. Some implications based on the results have been made.

1247 Using a Mixed Method Research Design to Evaluate the Learning Impact of Educational Escape Rooms

Georgios Villias, Mark Winterbottom

University of Cambridge, Cambridge, United Kingdom

Abstract

This study investigates thoroughly the design and practical application of a multi-dimensional educational approach, namely the Educational Escape Rooms (EERs). Making a reference to their educational potential in terms of facilitating learners to develop 21st century skills, the study attempts to acknowledge which of these 4Cs skills (Critical thinking, Creativity, Collaboration, Communication) are being practiced by students while engaging in an EER activity and whether a measurable development of these skills can be observed. From a practitioners' perspective, the research study seeks answers on how to optimize the design of these didactic interventions in the most efficient, practical and axiological manner. Regarding the study's outcome, the research led to a better understanding of these emerging educational

approaches, and specific connections were found between certain puzzle types and the practice of the 4Cs skills.

Parallel Session - 4.9 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Hakkı İlker Koştur

934 What Can Science Teachers Learn From the Humanities? Philosophical Dialogues to Trigger Reflection About Nature of Science

Jelle De Schrijver[1,2], Lotte Boven[1], Laura Vervacke[2], Laura Van den Broeck[2]

[1]Antwerp University, Antwerp, Belgium. [2]Odisee, Brussels, Belgium

Abstract

Enhancing explicit reflection about Nature of Science (NOS) is a key challenge for successful science education. Philosophical dialogues may scaffold this reflection process as this teaching method invites students to discuss philosophical questions by developing arguments and analyzing concepts. In a cyclical design-based research study, a prototype of a philosophical dialogue approach to NOS is developed and evaluated. The prototype is introduced in secondary schools and teacher training. Interviews with secondary school students and (student-)teachers allow to formulate design criteria as well as to pinpoint opportunities and challenges of this teaching method. Design criteria entail the role of a teacher as a facilitator and the importance of coupling philosophical questions to (de)contextualized teaching activities. Students and teachers affirm that introducing this dialogic approach is an opportunity to help students explore multiple perspectives about science. Yet, facilitating the dialogue is considered challenging as it isn't easily mastered.

998 Herstories as Histories: Women Scientists' Biographies as Windows to Understanding the Nature and Limits of Science

Aswathy Raveendran

Homi Bhabha Centre For Science Education, TIFR, Mumbai, Maharashtra, India

Abstract

Through a decolonial lens, this paper examines biographical material of two prominent women scientists of the early 20th century to discuss the nature and limits of scientific knowledge. These include the biographies of EK Janaki Ammal and Barbara McClintock, who were both plant cytologists and contemporaries. The paper attempts to highlight ways in which biographical material can be used to develop historical case studies of scientific practice and how it can be

discussed in science classrooms.

1117 Innovations, Challenges and Future Directions in Nature of Science Research: Reflections From Early Career Academics

Wonyong Park[1], Alison Cullinane[2], Haira Gandolfi[3], Sahar Alameh[4], Günkut Mesci[5]

[1]University of Southampton, Southampton, United Kingdom. [2]University of Edinburgh, Edinburgh, United Kingdom. [3]University of Cambridge, Cambridge, United Kingdom. [4]University of Kentucky, Lexington, KY, USA. [5]Giresun University, Giresun, Turkey

Abstract

There has been sustained research interest in the role of early career researchers in advancing the field and the challenges that they face. However, efforts to document lived experiences of researchers working in a specific research area within science education have been scarce. This paper considers the meaning of innovation in the context of nature of science (NOS) research, drawing from a collective reflection of five early career academics (ECAs) from different research traditions and education systems. From our own research experiences, we identify three distinct pathways of innovation in that area. These pathways include (1) delving into specific aspects of NOS in greater depth, (2) exploring the interface of NOS and other established research areas or pressing social issues, and (3) extending the methodological repertoire of NOS research. We illustrate these three modes of research innovation using examples from our own work. Barriers to early-career innovation such as the absence of NOS in curricula and teacher education, the lack of time to engage with practitioners to develop and implement resources, and the underrepresentation of diverse education systems in NOS research literature are discussed.

1134 Zooming in the Timeline: Investigation of the Case of Pseudo-Archimedes by Preservice Teachers

Hakkı İlker Koştur[1], Hasan Özcan[2]

[1]Başkent University, Ankara, Turkey. [2]Aksaray University, Aksaray, Turkey

Abstract

This study proposes a history of science undergraduate course inquiry activity in which collaborative groups research on the question of whether Archimedes designed a water clock or not. Participants of this activity were 40 undergraduate students who were registered in teaching programs in the faculty of education at a private university. The course approach was to teach history of science through a timeline with the support of weekly research questions and short activities. In this specific activity, participants carried out a research on the question and identified a group claim, based on evidence they collected. The course discussion resulted in comprehensive outcomes which aided the course's timeline-transition from antiquity to the middle ages covering the closing of the Platonic Academy, the birth of the house of wisdom, cultural and geographical factors in the translation movement and the concept of

pseudepigrapha. This activity covers a wide set of history, philosophy, and nature of science (HPNS) subjects and can be modified according to the time to be spent and the content of the course. Findings are discussed and reported with the necessary literary sources which are also expected to contribute to the contents and the atmosphere of the HPNS courses.

Parallel Session - 4.10 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Kok-Sing Tang

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371 Analyzing Classroom Discourse with Material Objects: Development & Comparison of Two Analytical Frameworks

Kok-Sing Tang

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Abstract

This paper presents and discusses two analytical frameworks developed to analyze teachers' and students' interaction with material objects during classroom discourse. Despite the advance in research on multimodality, there is currently no available framework, coding scheme, or method of inquiry to examine the use of material objects in science meaning-making, compared to frameworks that had been developed to analyze speech acts, diagrams and gestures. The first analytical framework is theoretically informed by multimodal interaction analysis (MIA) and it focuses on embodied modes of interaction as situated in the material world. The second framework is informed by a social semiotics approach to multimodal discourse analysis (SS-MDA) and it focuses on material objects constituting a unique semiotic mode (system of culturally shaped signs) that science teachers and students use to make meanings. Both frameworks are applied to several classroom interactions derived from video data in order to illustrate their applications, coding procedures, and relative affordances and limitations. The complementary connection between the two frameworks and the possibility of integrating them in classroom discourse analysis will be discussed.

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398 Turning Thinking from "fast^{2}slow": Dealing with Cognitive Biases

Joana Konrad, Annette Marohn

Institut für Didaktik der Chemie, Universität Münster, Münster, Germany

Abstract

Rational evaluation of facts requires evaluating a large amount of information. In the case of topics from the natural sciences, this is a challenge because studies and research results are interpreted differently. This affects social debates as well as everyone's cognitive processes and

thus also their lives. Triggers for this are one's own preconceptions, previous experiences, and prejudices, which unconsciously influence an evaluation process in the form of cognitive distortions. With the teaching concept "fast2slow", students learn on exemplary cognitive biases to realize them at themselves and others, that have their origin in fast, intuitive thinking. They get sensitised for the negative impact biases can have and learn to use strategies, that are related to the scientific way of working, to slow down thinking and to minimise errors that would influence their assessments. For this purpose, three cognitive biases where identified criterion-derived from the literature, that are relevant for the everyday life of students and the science education. A teaching concept with appropriate material for science teaching is in the developing-phase. It will be tested and improved in an iterative process.

594 Embedding Writing Instruction in High School Science

Helen Georgiou, Wendy Nielsen, Anette Turney, Honglin Chen

University of Wollongong, Wollongong, NSW, Australia

Abstract

Writing is an essential skill and improving students' writing ability is currently a priority in Australia. In this large-scale Australian-government-funded research project, a writing intervention was implemented in Science, History and English language classrooms in order to improve teacher and student outcomes. In this paper, we report on the results of an intervention involving science classrooms by presenting a case study school. Data include pre- and post-interviews with teachers, interviews with students, classroom observations, student writing samples at different time points, and instructional materials, including existing and amended unit plans and resources. The data were collected over two iterations of the intervention, corresponding to two school terms and therefore two individual topics (earthquakes and astronomy). Results reveal a significant change in teachers' perspectives of embedding teaching writing in science, improvements in students' writing, and overwhelmingly positive student perspectives. Some challenges were also noted, including initial hesitancy from teachers and tensions between writing aims and curriculum outcomes.

738 Science Teachers' Agentic Practice in the Pedagogy of Scientific Argumentation

Zeynep GULER

Ministry of Education, Ankara, Cankaya, Turkey

Abstract

Scientific argumentation has been acknowledged as a significant scientific practice, yet research has shown that science teachers have difficulty implementing this approach into science learning and teaching. Drawing on the concept of teacher agency, this qualitative study aims to achieve a more comprehensive understanding of science teachers' pedagogical development of scientific argumentation as a new approach. An analytical framework was

derived from a perspective of teacher agency as consisting of four components: a teacher's sense of purpose, mastery, autonomy to act, and reflexivity. Three science teachers with a background in science education took part in the study over a two-year period. Data sources included video-recorded classroom practices and audio-recorded teachers' reflective interviews. A comparative case study analysis showed that all three teachers demonstrated some development in agency and agentic practice during their implementation of an argumentation approach, but not to the same extent. The analytical framework served to show how the concept of agency may be useful as a valuable basis for evaluating the pedagogical development of a new teaching approach.

Parallel Session - 4.11 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Lucy Avraamidou

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28 What Are the Effects of IT-Enhanced Design-Based STEM Learning on STEM Creativity and Epistemic Beliefs? Implications for Integrated STEM Education in Primary Schools

Zhi Hong Wan

The Education University of Hong Kong, Hong Kong, China

Abstract

Integrated STEM education has been the focus of recent curriculum reforms worldwide. STEM learning is a distinctive and significant approach to achieving STEM integration. Although studies have investigated various outcomes of design-based STEM learning, not many have examined its influence on two significant outcomes - STEM creativity and epistemic beliefs - especially in design activities incorporating information technology (IT). In this study, we adopted mature instruments to investigate the effects of participating in a 6-month IT-enhanced design-based STEM learning event on 155 upper primary students' STEM creativity and epistemic beliefs. The results showed (i) a significant improvement in the fluency and flexibility dimensions of STEM creativity, (ii) a significant decrease in the source, certainty, and justification dimensions of epistemic beliefs, and (iii) no statistically significant change in the originality dimension of STEM creativity or the complexity dimension of epistemic beliefs. Moreover, we found a significant and negative correlation between STEM creativity and the source, certainty, and justification dimensions of epistemic beliefs, but a significant and positive correlation between STEM creativity and the complexity dimension of epistemic beliefs. The findings of this study generate additional evidence to support design-based STEM learning as a meaningful and feasible approach to achieving STEM integration in primary schools. Suggestions are made on how to design and implement integrated STEM education in primary schools.

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568 In-Service Teachers' Collaborative Stem Design Practices

Argyris Nipyrakis[1,2], Dimitris Stavrou[1], Lucy Avraamidou[2]

[1]University of Crete, Rethymnon, Greece. [2]University of Groningen, Groningen, Netherlands

Abstract

Design practices is a contemporary educational goal for both students and teachers. However, we lack understanding of how STEM design is been affected by disciplinary backgrounds. The present study investigates S-T-E-M teachers' STEM design practices during a Professional Development (PD) programme, in which teachers (n=26) collaboratively design and develop STEM teaching modules and artefacts. Qualitative content analysis of their discussions reveals insights about the nodes' design activity and contribution, as well the central themes discussed. Findings support that disciplinary background affected teachers' engagement with discussion themes as well as the parts of the artefact they undertook to develop. However, central nodes appeared from all S-T-E-M backgrounds. Common themes discussed by teachers include modelling, practicals, and robotics. Implications for the STEM PD programmes are discussed.

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803 Assessment of the Impact of a Transdisciplinary STEAM Approach on Students' Attitudes Towards Science and Learning of Physics Concepts

Sumeyra Hallac-Karakapici, Feral Ogan-Bekiroglu

Marmara University, Istanbul, Turkey

Abstract

Raising students who are equipped to adapt to the advancements in the industry has become a paramount objective in the realm of education. To achieve this, STEM education, which integrates the disciplines of science, technology, engineering, and mathematics, is increasingly being utilized in educational systems. STEM education encompasses several branches, one of which is the increasingly popular STEAM approach that incorporates art to foster critical thinking and creativity. However, there is a lack of standardization in implementation of STEM or STEAM curricula across the nation, and impact of these programs on students is not being evaluated. This study included the development of a novel, evidence-based transdisciplinary STEAM instructional program, and examined its effects on students' understanding of physics concepts and their attitude towards science. This semester-long program encompassed five distinct modules, designed by using an evidence-based approach. The modules were implemented in a ninth-grade physics class for one semester and both qualitative and quantitative research methods were used to collect and analyse data. It was concluded that the transdisciplinary STEAM program had positive effects on students' attitudes toward science and learning of physics concepts.

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947 Exploring Students' Conceptual Errors Regarding Atomic Structure in Grade 10 Physical Science

Doras Sibanda[1], Kevalan Moodley[1], Mary-Anne Good[2]

[1]University of KwaZulu-Natal, Pietermaritzburg, KwaZulu-Natal, South Africa. [2]University of KwaZulu-Natal, Durban, KwaZulu-Natal, South Africa

Abstract

The atomic structure problems experienced by learners are amongst the most complex and difficult in chemistry education. Conceptual errors in abstract topics hinder learners' understanding of chemistry topics at high school. This study aimed to explore students' conceptual errors regarding atomic structure in grade 10 Physical Science. Data was collected from a validated diagnostic test and 75 grade 10 Physical Science students completed the questionnaire and four group interviews were conducted with students. Data was analysed using descriptive statistics and content analysis respectively. The findings indicate that students experienced learning difficulties associated with atomic models, structure and orbitals. The findings of this study illustrate the need for developing teaching and learning strategies that will remediate these student conceptual difficulties to improve students' understanding of the atom and related chemistry topics. An understanding of the nature of the conceptual errors displayed by students might improve the quality of teaching the atomic structure.

Parallel Session - 4.12 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Xiao Huang

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834 Proposed Socio-Scientific Issues Based Science Teachingpractices of In-Service Science Teachers: Do Teaching Orientations Matter?

Büşra Aksöz, Devrim Guven

Boğaziçi University, İstanbul, Turkey

Abstract

Teaching science through socioscientific issues (SSIs) is one of the prevalent issues in science education. Science educators emphasise that inclusion of SSIs in science teaching provide many benefits to students such as gaining critical thinking, inquiring, decision making, ethical and moral reasoning, argumentation skills, and promoting civic engagement and citizenship (Zeidler, 2014). Research suggests that teachers' teaching orientations influence how scientific issues are handled in science lessons (Cobern, et al., 2014). The current study aims to determine middle school in-service science teachers' science teaching orientations and their proposed inclusion of SSIs in their science teaching. Twenty-one science teachers with varying years of

experience filled out Turkish version of the Pedagogy of Science Teaching Test (POSTT-TR) (Guvenc & Sert, 2013), participated semi-structured interviews about their typical science teaching practices and their proposed SSI based science teaching for the first step of the sequential exploratory mixed-method design study. Then, six teachers (3 teacher-centred, 3 student-centred) who have displayed consistency in their overall teaching practices based on POSTT-TR and interview were identified for the second phase of study. Finally, qualitative analysis was conducted for 6 teachers to determine how science teachers with varying teaching orientations propose to include SSIs in their science teaching. The findings indicated that all teachers regardless of their teaching orientation need professional development for an effective inclusion of SSI in their science teaching practices.

1017 Pre-Service Science Teachers Training to Work With Socioscientific Issues in a Community of Practices – the Construction of Knowledge Base for Teaching

Rita Prata[1], Edgar Miranda[2], Anderson Marinho[2]

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Abstract

This text presents an analysis of the perception of pre-service biology teachers about the contributions of the participation in a community of practices (CoP) for their professional development and professional identity. For that, texts produced by the pre-service biology teachers in the context of a community of practice dedicated to the training of pre-service and in service teachers to work with the approach of Socioscientific Issues (SSI) were analysed. The methodology employed were content analysis, and the categories were based on the knowledge base for teaching. Results shows that the work in CoP can be a potent methodology for teachers' education to the work with SSI, as it contributes to the construction of a broader representation of complex and socially relevant topics by pre-service science teachers

1038 Issue Familiarity as a Predictor of Turkish Middle School Students' Informal Reasoning Regarding Socioscientific Issues

Cansu Başak Uygun, Özgül Yılmaz Tüzün

Orta Doğu Teknik Üniversitesi, Ankara, Turkey

Abstract

The present study investigated how well Turkish middle school students' issue familiarity predict their informal reasoning modes (in terms of the total number of subject areas used) regarding three different SSI, namely, space explorations (SPE), genetically modified organisms (GMO), and nuclear power plants (NPP). Correlational research design was adopted, and a total of 465 students constituted the sample. Instrument of the study included Demographic Information Form, SSI Survey asking students' argument, accompanying reasons, and counter-

argument(s), and Issue Familiarity Form developed by the researchers. Students' written arguments were coded based on the SEE-SEP Model including six subject areas (sociology/culture, environment, economy, science, ethics/morality, policy). Descriptive analyses indicated that the middle school students' informal reasoning modes varied across different SSI. It was also revealed that the students were able to consider multiple perspectives (i.e. using more than one subject area regarding GMO and NPP, and more than two subject areas regarding SPE) while negotiating SSI. Regression analyses showed that students' issue familiarity significantly predicted their informal reasoning modes (in terms of the total number of subject areas used) regarding the SPE and NPP topics. However, the students' issue familiarity was not a predictor of their informal reasoning modes regarding the GMO topic.

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696 Scientists' Views and Media News about the Nature of Science in COVID-19: A Case of Socio Scientific Issues

Xiao HUANG[1], Jiaxin BAI[1], Yingce WU[2], Tengjing WANG[1]

[1]Zhejiang Normal University, Jinhua, Zhejiang, China. [2]China Association of Higher Education, Beijing, Beijing, China

Abstract

The COVID-19 global pandemic is an important socio-scientific issue (SSI) and a topic that can be covered as part of explicit teaching of NOS. This study attempts to explore the methods and paradigms of NOS teaching with SSI. News from mainstream media in the People's Republic of China (e.g., People's Daily) and papers from key journals were collected for coding and analysis according to the timeline and theme. The seven dimensions of NOS were analysed and the views of scientists and news about NOS were given. The research results show that the key aspects of contemporary NOS come from the concentrated and detailed research history of COVID-19. Although most NOS aspects are hidden, we can teach various NOS aspects in a clear way by using COVID-19, a familiar SSI for the public.

Parallel Session - 4.13 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Fatma Çağlın Akıllıoğlu

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161 "How do we know What we know?": Nature of Science in Human Evolution Exhibits

Anna Pshenichny-Mamo, Dina Tsybulsky

Technion - Israel Institute of Technology, Haifa, Israel

Abstract

One of the challenges of Natural History Museums (NHMs) is to present different aspects of science, such as the fact that scientific knowledge is not static while attempting to make science an enjoyable experience for visitors. Understanding these facets can contribute to a more comprehensive understanding of the Nature of Science (NOS). This study examined the integration of NOS in NHMs in the contents of exhibits on human evolution by applying the family resemblance approach framework, which suggests that NOS can be broadly defined as reflecting cognitive-epistemic and social-institutional features of science. A content analysis of written signages, video presentations, and semi-structured stimulated-recall interviews with museum staff showed how the NOS emerges in exhibits in three NHMs located in Tel Aviv, Copenhagen, and Stockholm. The results show that integrating NOS in NHMs is complex. The conceptualization of approaches for NOS integration in the context of informal learning is suggested. Overall, including NOS in exhibit content can contribute to educating citizens to harness their science capital and base their decisions on scientific knowledge.

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421 Students' Meaning Making of Nature of Science: Interaction Between Visual, Verbal and Written Modes of Representation

Kason Ka Ching Cheung, Sibel Erduran, Alis Oancea

University of Oxford, Oxford, United Kingdom

Abstract

Nature of science (NOS) can be expressed in visual, written, or verbal modes. Research in NOS education characterized students' understanding by their drawings, written texts and verbal discourse. However, there are only a few research studies examining how these three modes interact in collaborative discussion. Drawing on the theories of multimodality and social semiotics, this proposal aims to present findings on how visual, written, and verbal modes interact when junior secondary students generated their representations of NOS in relation to the instructional content. This study utilizes a collective case study approach, videotaping how two focal groups of students in two grade seven science classes in Hong Kong generated their multimodal representations of NOS. Three modes interact and contribute to meaning making of NOS in four ways: (1) bridging students' discourse of scientific methods through interacting with materiality of nature of scientists; (2) opening up a semiotic space for contextualized NOS understanding; (3) reorganizing discursive scientific practices into scientific method; and (4) representing social aspects of science through embodied semiosis.

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702 The Influence of History of Science Supported Activities on University Students' Nature of Science Beliefs

Uygar Kanlı[1], Duygu Yılmaz Ergül[1], Hilal Yanış Kelleci[1], Hakki İlker Koştur[2]

[1]Gazi University, Ankara, Turkey. [2]Baskent University, Ankara, Turkey

Abstract

In this study, it is aimed to examine whether history of science (HoS) activities have effects on the beliefs of university students from different disciplines about the nature of science (NoS). In the light of the purpose of the study, the activities supported by the HoS were designed to gain an understanding of university students (n=85) who took the elective course entitled "History of Science" in the faculty of education. Activities from the history of science, such as Archimedes' Crown, Pythagoras' Cup of Justice, Eratosthenes' measurement of the circumference of Earth, Alhazen's Camera Oscura, etc., were carried out within two hours for 14-week in the course. The VNOS-C forms was applied as a pre- and post- test and semi-structured interviews to determine the students' beliefs on NoS. When the results were analyzed with descriptive statistics, it was seen that HoS activity supported courses enrich and improve students' understanding of NoS.

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872 The Discursive Choices of Nature of Science Epistemic Communities

Fatma Çağlın Akillıoğlu[1], Semra Sungur[2], Jale Çakıroğlu[2]

[1]Kütahya Dumlupinar University, Kütahya, Turkey. [2]Middle East Technical University, Ankara, Turkey

Abstract

The characteristics of discourses are determined by epistemic communities since these communities influence the construction of discourse processes and practices (Kelly, 2014). Therefore, it is reasonable to assume that discourses promoted by epistemic communities of science education can be distinguished through their discursive choices. The investigation of these communities revealed the significant presence of nature of science (NOS) framework in science education, which further led to the investigation of the discursive choices of the NOS epistemic community in both science and elementary science education literature to explore the influences of discourse. Therefore, a critical discourse analysis (CDA) perspective was adopted as the methodological approach, and Fairclough's (2001) triadic CDA approach was utilized. For the sampling procedure, a co-citation analysis was conducted to locate the epistemic communities, and Lederman's (1992) and Akerson, Abd-El-Khalick, & Lederman's (2000) articles were purposefully sampled for the NOS epistemic community in science education and elementary science education literature, respectively. The findings revealed that nominalizations, "conception," "understanding," "view," and "belief" of nature of science were characteristic choices of the NOS epistemic community in science education literature and frequently used interchangeably, even though the nominalization "conception of nature of science" was favored. Conversely, the nominalization 'view of nature of science' appears to be a favored and competing discursive choice to the 'conception of nature of science' in elementary science education literature. Depending on the perceived authority, one of these nominalizations is utilized. If the text aims to appeal to NOS epistemic community in general, 'conception of nature of science' is used, even if it causes terminological inconsistencies within the text. These findings suggest that there is no established terminology for the commonly used

variable or distinguishing definitions for the variables used in studying NOS, revealing that the epistemic communities' discursive choices determine what is being researched.

Parallel Session - 4.14 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Chadia Rammou

390 Framing Ethical Issues About Climate Change on Climate Justice to Explore Pre-Service Teachers' Ethical Reasoning

Cicek Dilek Bakanay, Deniz Saribas

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Abstract

Climate crisis is an ethical issue besides being an environmental problem. Therefore, examining pre-service teachers' ethical reasoning about climate change is crucial since they will create future global citizens. Since climate change is an interdisciplinary field, not only science teachers but also English Language teachers are supposed to include reading activities on environmental topics in their classes and thus, contribute to their students' ethical values about these topics. Therefore, the purpose of this study is to investigate pre-service language teachers' ethical reasoning on climate change. We framed ethical reasoning on climate justice based on the theoretical background, which considers climate change as a social justice issue because disadvantaged communities are likely to be the most vulnerable to the impacts of climate change while they contribute least to causing climate change. The participants of the current study were 31 pre-service teachers (10 males, 21 females) who study in English Language Teaching Program in Faculty of Education at a private university in Turkey. The data was collected from the reflective forms that the participants filled and teaching designs that they created on climate justice (CJ). The results of the study revealed that while the participants generally emphasized CJ as the principles of social justice including human rights, access to resources, equity, participation in decisions on personal and social issues, they were challenged to design a teaching that would bring these values to the classroom. The findings of this study support the argument that a transformative pedagogy reframing climate change education on CJ is needed to prepare students for finding solutions of today's climate crisis. Designing teacher education programs considering the holistic and transformative pedagogy reframing climate change education on CJ may help for our sustainable future.

1222 Environmental Activism and Territory: Developing Spaces of Resistance in Zones of Socioenvironmental Conflicts Through Science Education

Bárbara González-Urzúa[1], Pablo Malhue[1], Corina González-Weil[1], Gonzalo Guerrero[2]

[1]Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile. [2]Univeristy College London, London, United Kingdom

Abstract

In Chile, there are areas with high industrial activity and environmental conflicts. From this perspective, we can ask ourselves how science education contributes to the defense of the territory and socio-environmental justice since, under the current curriculum implementation, we must focus on the discipline itself. A critical approach to science teaching can help develop activism in these territories, however, teachers with these practices face various tensions when carrying them out. That is why two biology teachers with activist practices in these areas of environmental conflict ask ourselves how do we signify environmental activism and territorial conditions from our teaching practise in areas of environmental conflict? Furthermore, how does environmental activism translates into our praxis, and what tensions emerge from it? We position ourselves in a qualitative paradigm under critical theory to answer them. We held six reflective dialogues in which we delved into our praxis. Through reflective thematic analysis, issues such as identity emerged and how our connection with the territory and sense of belonging is a banner of struggle to defend it; political, social, and epistemological tensions that shape our praxis and how spaces of resistance are generated that support the community through science education. Finally, we conclude that environmental education allows us to support the community in the face of conflict and encourage participation in resolving local environmental problems, helping to strengthen citizen and environmental education. However, as activist teachers, we must be aware of the risks such practices can mean in areas of environmental conflict.

1288 A Study on Climate Change Education at the Elementary School Level

Winnie Wing Mui So, Zeyu Han

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Abstract

Climate change has been recognised as one of the most pressing threats worldwide, and therefore warrants more attention in corresponding educational research and practice. Climate change education (CCE) has been argued to go beyond traditional science education, with its interdisciplinary characteristic highlighted. CCE is particularly notable at the elementary school level, with better accessibility and a more significant educational effect in this early schooling stage. The current study first comprehensively examined the existence of CCE-related curriculum content, teaching strategies, and extra-curricular activities in school education through a survey. The survey was responded to by around 200 elementary school teachers from nine different regions. Overall, the current situation of CCE is promising, especially in terms of

curriculum content and strategies. However, as an emerging educational intervention that echoes the interdisciplinary characteristic, video-watching was discovered to be relatively overlooked. We therefore attempted to investigate the potential effects of five animated videos related to climate change on students' change in knowledge and attitudes. Twelve elementary school students were invited to take part in in-depth interviews after video-watching. Results indicated a significant positive effect on fostering the prospective concepts and attitudes. The features of videos that contributed to students' change were identified for the future making of educational videos. This study has implications for the design and implementation of CCE at the elementary school level.

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907 Primary Students' Visions Regarding Environmental Factors Influencing Biodiversity in Specific Environments

Chadia Rammou, Arnau Amat

Universitat de Vic - Universitat Central de Catalunya, Vic, Barcelona, Spain

Abstract

The purpose of this paper is to study which environmental factors are considered by primary school students to explain the biodiversity of particular environments. The study is part of a project, which aims to understand and promote biodiversity in schoolyards through authentic inquiry-based science education. Data were collected before and after students' participation of this project through a set of two focus groups. It was conducted with 49 primary school students from three schools in an urban area. The results of either the first focus group and the second focus group show that children mostly consider biotic factors as a key factor in promoting biodiversity, mainly the presence of vegetation, and for this reason, identify forests and jungles as places with the greatest biodiversity. However, a gradual evolution was noted between the two focus groups mentioning in the second focus group for example which is the role of this vegetation in the particular environment. Abiotic factors, especially temperature and humidity, were mainly used as an explanation for the lack of biodiversity in deserts or polar zones, even if in the end they were considered as the habitat of some living being that we should also take into account. Finally, humans were initially mostly described as a limiting factor causing the loss of biodiversity, but this destructive view has now decreased.

Parallel Session - 4.15 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Einat Ben Eliyahu

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819 Slovenian Lower Secondary School Students' Understanding Lithosphere and Pedosphere Concepts

Luka Ribič, Iztok Devetak, Matej Vošnjak

University of Ljubljana, Faculty of Education, Ljubljana, Slovenia

Abstract

The contents related to lithosphere and pedosphere are part of environmental chemistry. In Slovenia there are no regulations in which subject environmental topics must be covered, but it is recommended that schools introduce some local environmental topics. The aim of this study is to investigate the level of knowledge about lithosphere and pedosphere in relation to final grade achievement in chemistry, biology and physics, region, gender, individual interest and self-esteem of students. In addition, our study aimed to investigate students' misconceptions about this topic. Based on a quantitative research approach, 503 students (254 male and 249 female) from 14 different primary schools and 8 different regions of Slovenia participated in this study. A three-tier achievement test (with ten three-part tasks to identify misconceptions) and a paper-pencil questionnaire (15 closed-ended questions to identify individual interest and self-esteem in learning content about lithosphere and pedosphere) were used to collect data. Results show that final grade achievement in chemistry, biology, and physics had a statistically significant effect on the scores on three-tier achievement test. Students from predominantly rural regions had statistically significant higher scores on written test than students from intermediate regions. There were no statistically significant differences between gender and scores on three-tier achievement test. Students with higher level of individual interest achieved statistically significantly higher scores on the three-tier achievement test. Female students had more misconceptions about lithosphere and pedosphere content than male students.

1196 Early Childhood Teachers' Knowledge of Common Local Species

Tuula H Skarstein

University of Stavanger, Stavanger, Norway

Abstract

To be able to provide children opportunities to learn about nature and learn to appreciate its diversity, it is important that early childhood (EC) teachers have both the knowledge and skills to facilitate the variety of learning possibilities that exist in natural environments. The aim of this study is to get a closer look at EC teachers' knowledge of common local species and their views

on the importance of species knowledge. The study included 167 EC teachers from 46 Norwegian kindergartens. Information was collected through an anonymous questionnaire consisting of a species identification test and close-ended questions. The results reveal a mean score of 60% correct answers for the species identification test. This can be considered as a relativity good score when compared with previous studies. The vast majority of the participating EC teachers find species knowledge important and use it in their work with children. It is, however, a matter of concern that one third of the teachers identified less than half of the species correctly. This emphasizes the importance of locally relevant species learning as a part of both preservice and in-service EC teacher education.

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167 DIY Fluorescence Microscopy for Detection of Microplastics with Secondary School Students

Sebastian Tassoti, Alina Majcen, Spitzer Philipp

University of Graz, Graz, Austria

Abstract

Microplastics are small plastic particles that are now ubiquitous in the environment. Their size is <5 mm and they accumulate in the human body via the food chain and water intake with limited knowledge of their health implications. In this series of student experiments, we enable secondary school students to identify microplastic particles qualitatively in a low-cost-approach. Starting from a microplastic-contaminated sediment sample, students use sieves and floatation to separate plastic particles from most other particles and to some extent organic matter. The fluorescent dye Nile red stains plastic particles, making them detectable in a DIY low-cost fluorescence microscope. The experiments were used with students in secondary school chemistry courses as well as for school students' theses (austrian 'Vorwissenschaftliche Arbeit', a small mandatory thesis at the end of secondary school). There, they left an immediate impression with the audience, highlighting the problem of environmental pollution by (micro-)plastic particles.

1056 Comparing Pictorial, Verbal and Mixed Multiple-Choice Assessments of Middle School Chemistry Concepts

Einat Ben Eliyahu, Elon Langbeheim

Ben Gurion University of the Negev, Beer Sheva, Israel

Abstract

The representational format of testing items is often taking for granted, although it may have a significant effect on students' performance on concept tests. More specifically, visual representations, can sometimes clarify the idea that is examined, but they can also pose additional conceptual barriers for students who are not familiar with the information embedded in the picture. Our study aims at determining whether assessments of basic chemistry ideas, are equally reliable when presented in visual representations, verbal statements or a combination

of the two. We developed three versions of the same assessment which were randomly assigned to 109 ninth graders. We found that the pictorial version of the questionnaire was more difficult than the other two formats, and found a significant correlation between the total scores and the clarity of the questions only in the pictorial version. We believe that students' differences in representational competence, explain much of the difference between their performance on pictorial version when compared to the other two versions.

Parallel Session - 4.16 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Yvoni Pavlou

30 School Science Clubs: A Glance of Teachers' Perceived Professional Development

Jorge Martín[1], Ana Afonso[2], María Eugenia Dies[1]

[1]Universidad de Zaragoza, Zaragoza, Aragón, Spain. [2]University of Minho, Braga, Portugal

Abstract

Learning is a dynamic process and learning to teach occurs across different contexts and is not limited to school classroom. Therefore, it is necessary to explore what non-formal science contexts can bring to teachers' professional development. This study, in the context of school science clubs that are part of a network, analyses how this setting can promote teacher's professional development. The analysis of the current eight semi-structured interviews, conducted with mature teachers that run a science club, revealed that for them the participation in the club enhances their professional development at a personal, social and professional level. Since the science clubs are part of a network of school clubs there is a need to rethink how this network can improve science clubs to better contribute to the professional development of the participating teachers.

185 What Types of Experimental Activites are Appreciated by Students Inclined Towards Studying STEM?

Alexandr Nikitin, Marie Snětinová, Petr Kacovsky

Department of Physics Education, Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic

Abstract

Our department offers several experimental activities for upper-secondary school students. These activities vary in their respective characteristics, which may appeal differently to various groups of students. This contribution focuses on three specific activities – pure lecture

demonstrations, popularizing demonstrational shows and practical lab work. A questionnaire based on Intrinsic Motivation Inventory was administered to students attending these activities. The relationship between situational interest triggered by these activities and students' intention to study STEM at university level was analysed using two-way ANOVA. The results show that any experimental activity triggers more interest in students prone to studying STEM, yet the capacity of practical work to trigger interest drops most rapidly (out of the three types of activity) with the decrease in intention to study STEM. Popularizing demonstrational shows trigger most interest in all students, yet for students prone towards studying STEM it is comparable to interest triggered by practical lab work.

384 What Makes an Interesting Science Gallery?

Joshua Loh, Tang Wee Teo

National Institute of Education, Singapore

Abstract

In this study, we observed how people navigated a science gallery using mobile eye-tracking technology. We were able to find out how people moved within the gallery, as well as identify exhibits that captured the attention of visitors. Mobile eye-tracking technology provides a level of detail that conventional methods such as video recordings or interviews are not able to, such as finding out which specific artefacts within the exhibits that people were interested in. By thinking of a gallery in its exhibits and artefacts, we can clearly determine why certain exhibits are more attractive to visitors, based on what elements they contain. Based on eye-tracking data, and using average attention ratio as a metric, we found that participants spent more time at exhibits with artefacts that had interactive elements. Additionally, the attention of participants at each individual exhibit were concentrated at those interactive elements. The findings of this paper could be used by museum curators and educators. Museum curators could purposefully and tactfully include some form of interactivity into their exhibits. Teachers can now maximise students' learning on their next visit to the science museum, by planning general routes that include more interactivity, to hold their students' attention better.

408 The Impact of Open Schooling Projects on Students' Perceptions on the Control of Their Learning

Yvoni Pavlou[1], Marios Papaevripidou[1], Georgia Kouti[1], Marilena Savva[1], Zacharias C. Zacharia[1], Pavlos Koulouris[2]

[1]University of Cyprus, Nicosia, Cyprus. [2]Ellinogermaniki Agogi, Athens, Greece

Abstract

Even though Open Schooling (OS) is a promising approach for facilitating community-based learning and the interaction of schools with external stakeholders, our understanding of how this approach is enacted in schools is still very limited. This study aims at exploring how OS was

enacted by schools during an academic school year in the context of an EU-funded project and whether students' engagement in relevant school projects impacted their perceptions of the control they believe they have over their learning. The participants of this study were 80 teachers and 330 students from 40 schools. Each school provided a portfolio describing their OS project and students completed a questionnaire before and after the school implementations. Open coding was performed for analyzing the data retrieved from the school portfolios, whereas students' responses in the questionnaire were analyzed with parametric statistics. Five pathways emerged from the analyses portraying the actions and deriving outputs of the school projects. The pathways differentiated in terms of either the sequence of actions carried out during the planning phase of the projects and/or the presence/absence of stakeholders' contribution in specific actions/outputs. Only students participating in projects of one of the pathways seemed to have significantly developed their perceptions of their control over their learning. The findings of the present study can enhance our understanding in terms of how OS is enacted in school contexts and for generating recommendations for future OS initiatives.

Parallel Session - 4.17 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Jonathan Berliner

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712 Prospective Elementary Teachers' Science Teacher Identity Development in Informal Learning Settings

Emily Michailidi

University of Crete, Rethymnon, Greece

Abstract

In this study we focus on the use of a network of informal science institutions as sites for prospective elementary teacher preparation. Using a framework of identity, we describe the affordances of the different informal learning settings and how these affordances support prospective elementary teachers in developing broader understandings of science and science teaching. The 18 prospective teachers that participated in the study were trained in a research center, a paleontological museum and a science center and developed teaching activities for these settings. Data collected through journal entries, lesson plans, group interviews and records of plenary reflective meetings reveals the material, societal and cultural resources teachers mobilize to (re)shape their science teacher identity and calls for a science teachers' preparation in settings where different representations of science, science practices and science learning are prominent.

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840 Gendered Learning Environments: Constitution of the Celebrated Student in the STEM Classroom

Gry Thorsen, Henriette Tolstrup Holmegaard, Lene Møller Madsen

Department of Science Education, Copenhagen, Denmark

Abstract

This proposal is concerned with the challenge of recruiting more women and girls into science and engineering programs. The outset of the study is the fact that many science classrooms seem to be gendered in ways that favors masculinity (Danielsson, 2014). The proposal discusses how the learning environment at a three-year, non-compulsory upper secondary school is gendered and how this gendering is closely connected to an implicit ideal of the celebrated student in the science classroom. The study builds on feminist, poststructuralist theory and critical masculinity studies and combines this theoretical outset with ethnographic fieldwork. Through analysis of empirical findings obtained through in-depth participant observations in two science classrooms the authors show that the celebrated student position in the chemistry lab is a white, masculine position. The position as celebrated student is co-constituted through social processes of interactions between the students and between the students and the teacher. Participant observations allow for nuanced and detailed descriptions of the social processes through which identity is constituted. The position of the celebrated student is not challenged in the interactions in the classroom and thus the implicit ideal of the celebrated student seems to be reproduced and emphasized through the same social processes that constitute it.

1034 Desire-Based Research for Alternate World Building: Possibilities and Tensions for Research in STEM Education

Sarah El Halwany[1], Rachael Edino[1], Sophia Marlow[1], Nadia Qureshi[2], Kristen Schaffer[3], Kristal Turner[1], Jennifer Adams[1]

[1]University of Calgary, Calgary, Canada. [2]University of Toronto, Toronto, Canada. [3]Mount Royal University, Calgary, Canada

Abstract

In this paper, we engage with a desire-based framework to think with Black, Indigenous and People of Colour (BIPOC) students' experiences in postsecondary STEM. In contrast to damage-centered research, desire-based research crafts stories and alternate worlds where agency and change take primacy over problems and harms faced by BIPOC students in STEM. This is important for interrupting damage-based narratives that continue to homogenize and subjugate BIPOC communities. We interpret BIPOC students' recounted experiences of harms and discrimination to attend to the multiplicity of/in desires for alternate projects of world-building around compassion, humility and belonging. We end with raising new ethical questions, tensions and contradictions that are inherent to our desires for analyzing data

differently.

1186 What Can the Life Stories of Neurodivergent Chemists Tell Us About the Inclusivity of Chemistry Education?

Jonathan Berliner

King's College London, London, United Kingdom

Abstract

Neurodiversity theory accepts that natural variations exist between humans in how they sense, process, and respond to their physical and social environments. Within different contexts, these can be impairments or enhancements, and are often described by medical diagnoses such as autism, ADHD, and dyslexia. Neurodivergent individuals commonly experience lower educational attainment and mental health outcomes as they are disadvantaged by neurotypical social structures, many of which exist in educational practice and research. Whilst most research in the field adopts a deficit model, this study's design is informed by neurodiversity theory, putting the focus on strengths, lived experience, and interactions of the individual with the environment. Purposive sampling was used to select three out of twelve semi-structured interviews with successful postgraduate neurodivergent chemists for narrative analysis. Stories were co-constructed from the interviews, which revealed diverse barriers, facilitators, challenges, and strengths, experienced by participants on their educational journeys. The summary of the life-story presented here is used as a case study to demonstrate examples of typical factors affecting a minimally verbal MSc chemistry student from London. Drawing on ideas from critical disability theory and special educational needs literature, the analysis supported an ecological model for neurodiversity in the classroom, whereby neurodivergent students require strength-based pedagogy and classroom adjustments to support the construction of sustaining learning niches in which they fit. The examples of barriers and facilitating factors within the stories provide suggestions for research, pedagogy, curriculum, and policy. The narrative analysis gave importance to the opportunities that chemistry studies afforded students to use their strengths. It was notable that chemistry studies provided a diverse range of opportunities reflecting the diverse range of cognitive and motor skills used in chemistry studies.

Parallel Session - 4.18 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Marta Romero-Ariza

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601 Investigating Undergraduate and High School Students' Identification With Physics Through Structural Equation Modeling

Danilo Catena[1], Italo Testa[2]

[1]University of Udine, Udine, Italy. [2]University Federico II, Naples, Italy

Abstract

In STEM education, the identity framework is often used to investigate students' intention to pursue a STEM-related career. The purpose of this study was to explore the relationships between physics identity, interest, recognition, and self-efficacy in physics, taking into account the role of gender in influencing these constructs and the role of previous experience with physics in moderating the relationships. The analysis was based on a Likert-scale survey aimed at measuring the addressed constructs, administered online to N = 1135 Italian high school and undergraduate – from physics and engineering courses – students. We validated a structural model in which self-efficacy affects physics identity, being mediated by interest and recognition. Direct effects are significant only for undergraduate students. The structural model appears to be invariant with respect to the previous experience with physics. Results have implications for instruction in terms of understanding the mechanism underlying the promotion of students' identity development in physics.

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820 Science for All! How to Make a Science Center Accessible for Persons With Disabilities? Reflections From the Field Study.

Marta Sałkowska

Copernicus Science Center, Warsaw, Poland

Abstract

This paper aims to reflect on a research process that should make Copernicus Science Center more accessible for D/deaf and blind persons. I present the background of the inquiry by proving that accessibility of science centers may be more complicated and needs a more innovative approach than the accessibility of museums of art. Research was conducted within the disability studies paradigm that requires participation and inclusion of persons with disabilities according to the motto "nothing about us without us." Among research participants, there were bling and D/deaf persons. Both sociological observations and group interviews were accompanied by sign language interpreters. Various working methods were applied to make the research group engaged. This paper focuses on a methodological reflection so it does not present the results of the study but the way it was conducted. Researchers doing

research with and among disabled persons have to be more flexible and more focused on the study results than methodological purity. Research techniques, communication, and working methods have to be adapted to the needs of participants. The research was challenging but when researchers stay open-minded they will gain an opportunity to learn and discover new research possibilities. Researchers need to be flexible and prepared for constant changes in the process. Interviews (or rather consultations or workshops) should be scheduled for a longer time than a standard meeting – communication mediated by sign language interpreters takes more time. As banal as it may sound – researchers have to be prepared for the meeting and search for insights and expertise from more experienced researchers. Reflect on the research process and your role in it. Require feedback both from research participants and from research team members.

943 Science for Social Justice: Case Studies of Novice and Experienced Science Teachers

Katherine Wade-Jaimes

University of Nevada, Las Vegas, NV, USA

Abstract

This proposal explores how teachers enact social justice science teaching identities in science classrooms. As part of a larger study, interview and written reflection data was collected over one academic year from both novice and experienced teachers. Analysis of the data showed that while all teachers found ways to enact social justice science teaching identities, novice and experienced teachers did so in different ways. The experienced teachers were able to critique and adapt curriculum, including mandated testing, but were not able to identify the impact of oppressive structures in education. Novice teachers were more likely to identify oppressive structures, but struggled to identify ways, either inside or outside of the science classroom, to disrupt them, and rarely attempted to critique or adapt curricular materials. All teachers relied on respectful and caring relationships with students and strong science pedagogy, rooted in inquiry-based learning, as the foundation of their teaching identities.

1115 Female Role Models Are Key to Build a Empowered-Girls STEM Community

María Martín-Peciña, Antonio Quesada, Ana M. Abril, Marta Romero-Ariza

University of Jaén, Jaén, Spain

Abstract

The under-representation of women in STEM-related sectors is a fact that hinders science from showing its full potential as a solving tool for global challenges concerning the whole human population. Reasons behind this situation are heterogeneous but it is a structural issue for society rooted from early years. The GEM summer camp was a fruitful initiative to enhance the STEM potential in girls using as angular stone brilliant female scientists, entrepreneurs and

experts in digital sectors who acted as close role models for girls. They enjoyed a week of real research getting involved in cutting-edge and socially relevant STEM projects working in small groups and guided by excellent female mentors. The camp allowed the building of a gender-inclusive STEM community of girls, families, mentors and lecturers perceiving the initiative as a very positive learning experience which increased girls' interest in science and in the STEM world of work. In light of the research evidences found here, it is highlighted which and how female role-models can make a meaningful contribution in terms of embracing STEM potential through the building of a community.

Parallel Session - 4.19 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Franz Schröer

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770 Being Gifted and a Middle Eastern Girl: Possible Scientific Identities and Funds of Scientific Knowledge Within the Framework of Activities to Encourage Girls in Science and Being a Scientist

Gül İrem Özen, Gamze Babaoğlu

Gazi University, Ankara, Turkey

Abstract

This case study explores (1) how science is socially and culturally constructed via activities to encourage girls in Science and Being A Scientist (2) gifted middle eastern girls how to define themself as possible scientists at the intersection of these two patterns. The participants of this study consisted of 8 girls aged 10 selected from a Science and Art Center in Central Anatolia in Turkey. The data gathered through semi-structured interviews and field notes was analyzed by content analysis. The results revealed that the girls cannot define themselves as scientists in the future, even though they are gifted and come from a high socio-economic level, although their interests are supported by their families. Although some of them could not define themselves as scientists at the beginning, they were able to define themselves as scientists as a result of the activities to encourage girls in Science and Being A Scientist. Girls gathered FoSK such as fields "Science includes complex FoK, Science is locally and globally relevant, Science is a relational, social experience, Science is performed, personified, and played" with activities to encourage girls in Science and Being A Scientist.

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968 Demographic Inequalities Across Assessment Types in University Physics

Jessie Durk, Michael Fox, Camille Kandiko Howson, Amy Smith, Mark Richards

Imperial College London, London, United Kingdom

Abstract

The relationship between assessment type and academic performance of underrepresented undergraduate physics students compared to overrepresented students was investigated at a research-intensive university in England. Informed by current literature, we looked at gender, students' parental education as a measure of socioeconomic status, and ethnicity. We conducted quantitative analysis of historical data and found assessment type to be a factor when considering gender, but not for students' parental education or ethnicity. Compared to male students, female students scored statistically significantly lower on average on modules where the dominant form of assessment was via a written exam, with no difference for modules that were lab or coursework based. However, both students whose parents did not attend university, and ethnic minority students, scored lower than their counterparts, regardless of assessment type. Our findings agree with previous studies, suggesting broader, underlying patterns regarding assessment type and inequalities in learning outcomes by demographic. We propose reasons why female students experience such a 'written-exam' effect in this context, highlighting the need for future studies to further explore these issues and considerations to be made about how assessment is carried out in higher education physics.

1267 Achieving Gender Equality through STEM Education in UAE University over a decade: Analyzing Gender, Racial and Ethnic Participation

Ahmad Qablan, Shashidhar Belbase, Hassan Tairab

United Arab Emirates University, Al Ain, UAE

Abstract

Science, Technology, Engineering, and Mathematics (STEM) has been one of the top educational priorities of several countries to promote 21st-century skills with creativity, critical thinking, collaboration, communication together with problem-solving. This study aimed to identify UAE university students' preference for STEM subjects and the percentage of those who earn a university degree in any STEM subject. The sample consisted of all male and female students who had enrolled and graduated with a degree in any of the STEM fields between 2010 and 2022. The total number of students was 149,866. Data analysis revealed a disparity in preferences and percentages of UAE male and female students who enrolled/graduated in STEM subjects. The preliminary findings show a huge disparity in preferences and percentages of UAE males and females who enrolled in STEM subjects throughout the years (2010-2022). Both the rate of enrollment and graduation of UAE national male students in all STEM subjects is way higher than that of UAE national female students across all years. Additionally, both the rate of enrollment and graduation of both male and female UAE students remained stable throughout the years in all STEM subjects. Such results indicate that the UAE government's policies to bridge the gender gap among UAE national students have not reached the target indicated in the national agenda of 2030. The study attributes that disparity to the job market's hiring preferences. The study suggests certain multisectoral changes to address gender

disparity and sparks UAE women's interest in pursuing STEM education.

777 'Sachunterricht' and Inclusion at Primary Level - an Empirical Study About the Nature and Consideration of Pupils Needs in Interdisciplinary Science, Social and Technological Studies

Franz Schröer

Universität Paderborn, Paderborn, Northrine-Westphalia, Germany

Abstract

Research on technology education within interdisciplinary science and social studies ('Sachunterricht') in German primary schools emphasizes that children are generally interested in technology. Several STEM initiatives point towards a growing recognition of technological literacy as a key to participation in a society that is shaped by technology and its development. However, the consideration of and engagement with technology education in the multiperspective primary school subject 'Sachunterricht' is quite underrepresented in practice as well as in research and teacher training. Considering the UN-CRPD claims for an inclusive educational system and thus the right to equally participate in a free society, participation in society through participation in technology is a fundamental common goal of technological and inclusive education. Several common understandings of inclusive designs for teaching and learning make it reasonable to assume that the consideration of pupils' various expressions of needs form a potentially decisive element of inclusive education. It is however not yet well understood how teaching and learning arrangements can consider and satisfy the needs of all different pupils. The dissertation project the presented poster is part of was presented at ESERA summer school 2022 (Utrecht). The aim of the study is to unveil and describe the appearance of student's basic needs in relation to technological education for all children. The initial quantitative part of the study presented in Utrecht examined the subjective significance of basic psychological needs in interdisciplinary science studies in primary education to allow for a well-reasoned sample choice for subsequent interviews.

Parallel Session - 4.20 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Jonathan Osborne

184 The PISA 2025 Science Framework

Jonathan Osborne

Stanford University, Stanford, California, USA

Abstract

This presentation will introduce the framework that will be used for the OECD Programme for International Student Assessment (PISA) in 2025. It will explain what changes have been made since the last time science was the primary focus of assessment in 2015 and their rationale. Three particular features of note will be explored in this presentation. First, a new competency to assess students' ability to research, evaluate and use scientific information for decision making and action. Second, a new focus on environmental education and agency in the Anthropocene. And finally, a change in the focus from scientific literacy to a broader emphasis on the outcomes of science education.

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394 'Hyperspace' for Formative Assessment and Inquiry-Based Education: Learning Environment for In-Service and Pre-Service Teachers

Lukas Rokos[1], Iva Stuchlíková[2], Tomáš Janík[3]

[1]University of South Bohemia in České Budějovice, Faculty of Education, Department of Biology, České Budějovice, Czech Republic. [2]University of South Bohemia in České Budějovice, Faculty of Education, Department of Psychology, České Budějovice, Czech Republic. [3]Masaryk University, Faculty of Education, Institute for Research in School Education, Brno, Czech Republic

Abstract

This contribution introduces the virtual platform called "Hyperspace" as a comprehensive educational environment for in-service and pre-service teachers. The purpose of the development of the platform was to provide opportunity to observe, analyse and deeply reflect instances of inquiry-based education and formative assessment in classroom practice. The design of this environment is based on the core ideas of reflective practitioner, professional vision, or didactic analysis. The text briefly presents these background ideas, Hyperspace development, and its individual components and functions. A brief overview of the feedback from users who tested the beta version of this platform is also included.

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524 STEM Stereotypes: Scale Development and Validation

Zeynep Aydin[1], Kübra Kaya[1], Sevda Yerdelen-Damar[1], Felicity McLure[2]

[1]Boğaziçi University, Istanbul, Turkey. [2]Charles Darwin University, Darwin, Australia

Abstract

Understanding stereotypes that students hold of STEM careers is a vital concern for today's world and there are few studies addressing this quantitatively. Therefore, this study aims to develop and validate a scale that can reveal STEM stereotypes of students as a large-scale assessment. Additionally, as far as observed, this scale differs from previously developed ones in that it measures stereotypes related to general beliefs, gender and socioeconomic status (SES) under each STEM discipline, namely science, mathematics, technology and engineering,

and considers a set of 21 items for each STEM domain as sub-scales. The structure of the scale and choice of items were determined by careful analysis of literature about stereotypes. This study reports on the initial STEM stereotypes instrument design process as described by McCoach et al. (2013). The scale was tested on a sample consisting of 396 public middle school students. Four independent EFAs were performed for 21 items under the four STEM domains to identify the factor structure and pattern for each domain. All factor loadings of the items were higher than .40 which is appropriate, there are no cross-loadings, each item loaded to the hypothesized factor of the scale. A scree plot also showed that the conceptual framework of the three sub-dimensions for each STEM domain is supported. The reliability of the results is also supported by cronbach's alpha of the subscales which ranged between .78 and .94. STEM stereotypes that students hold are a barrier to choosing STEM careers. This scale is a much needed tool for use by teachers, researchers and policy makers to detect and address these stereotypes.

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237 Secondary School Science Students' Ecojust Engineering Designs and Normalization

John Bencze[1], Dave Del Gobbo[2], Majd Zouda[1], Sarah El Halwany[3], Sheliza Ibrahim[4], Gonzalo Guerrero[5], Michelly Peixoto[1]

[1]OISE, University of Toronto, Toronto, ON, Canada. [2]Peel District School Board, Mississauga, ON, Canada. [3]University of Calgary, Calgary, AB, Canada. [4]University of Toronto, Toronto, ON, Canada. [5]IoE, UCL, London, England, United Kingdom

Abstract

In many contexts worldwide, educators are encouraged to interrelate aspects of science, technology, engineering and mathematics (STEM). Among STEM education variants, promotion of engineering design and appreciation of for-profit engineering products seems particularly prevalent. While there are numerous defenders of such foci, several analysts suggest that STEM education initiatives often compromise students' awareness of adverse effects on living and nonliving things of powerful people (e.g., financiers) and groups (e.g., governments, corporations & transnational entities [e.g., The World Trade Organization]) on STEM fields and beyond. Accordingly, we report collaborative action research findings regarding a secondary school science teacher's teaching about such problematic relationships like 'regulatory capture' (biasing of government regulatory agencies [e.g., FDA]) and, for commodities they design, enabling of them to mobilize and normalize their value systems–possibly incorporating social and/or ecological justice priorities–across networks of mostly cooperating actants (dispositifs). Results suggest that students' visions of mobilizations of their values involved ontological, epistemological and axiological changes–to a great extent influenced by a mini-dispositif including actants like: congruent official curricula, supportive school leaders, the teacher's more holistic and politicized views about science and direct instruction with relevant applicable activities.

Parallel Session - 4.21 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Ruhan Circi

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655 Epistemological Implications of Different Methodological Approaches in Textual Data Analysis

Martina Caramaschi[1], Andrea Zanellati[2], Olivia Levrini[1]

[1]Department of Physics and Astronomy - University of Bologna, Bologna, Italy. [2]Deparment of computer science - University of Bologna, Bologna, Italy

Abstract

Non-structured textual data, common in science education research, has traditionally been analysed using qualitative methods. However, the current datafication process of society makes data-intensive computational methods an alternative methodological approach. Through a case study on 223 essays in the context of a future-oriented science education project, we show the comparison of two methods: Thematic Analysis and Topic Modeling. In particular, the focus is on the knowledge retrieved by the two analyses, in terms of how it is characterised and how it is time- and human-consuming. The complementary nature of benefits and limits of the two methods suggests the possibility to integrate the two approaches, paying attention not only at the methodological level but also, and mainly, at the epistemological one.

1057 Transgressing Methodological Boundaries: Playing With Different Ways of Writing

Paulina Bravo

Universidad Católica del Maule, Talca, Chile

Abstract

This proposal tries to illustrate the recent sociopolitical call to make explicit the political discourses within the science education field by proposing the transgression of methodological boundaries. This transgression was shaped in my doctoral thesis in the way it was written in an attempt to show my own thinking process seeking to provoke the discussion of new modes of representing research in science education.

1231 Using C-K Design Theory as a Methodology to Examine Students' Misconceptions in STEM Education

Yakhoub Ndiaye[1], Pascal Le Masson[2], Lucienne Blessing[1]

[1]Singapore University of Technology and Design, Singapore, Singapore. [2]MINES Paristech, PSL Research University, Paris, France

Abstract

Students' misconceptions are a very critical issue that have been addressed for decades. Yet, many approaches, research methods, learning progressions, etc. have been proposed to tackle the issue. Besides, and for instance, science education is abundant with conceptual changes theories that all attempt to describe the dynamics of student misconceptions. The scientific debate has been turning around for nearly half a century. A common goal is that they usually confront students' ideas, statements with the scientific ones through a cognitive conflict process within explicit instructions. Such approaches have shown their limitations (see literature for further details) as it is also known that misconceptions are undisturbed despite such instructions. Consequently, tackling the issue is so demanding for teachers that they often avoid addressing the issue and as a rational and creative approach is lacking. In this proposal, we explored an alternative approach from a design theory (DT) perspective, by examining the status of misconceptions and generative knowledge, in particular in the "concept-knowledge" (C-K) design theory. C-K design theory is a formal theory of creative design that helps to overcome fixation. It identified idea fixations as a core issue in the design process that should be addressed rationally, and assumes that learners' creative ideas can interact between two interdependent spaces with different structures and logics: the space of concepts (C) and the space of knowledge (K). Using C-K supported by some instructional design principles, we implement an individual protocol analysis focusing on an example of study to investigate students' formulations, i.e. how C-K DT can assist in overcoming misconception fixation to enable the generation of creative scientific ideas. We discuss the implications and limitations of C-K DT for STEM education.

1264 Students' Response Time on Next Generation Science (NGS) Tasks: Examination of Gatekeepers

Ruhan Circi

AIR, Arlington, VA, USA

Abstract

The digital assessment delivery systems collect process data, which represents student interactions with the assessment platform and the assessment tasks. The process data consists of time-stamped records of student actions or activities (e.g., highlighter use) and automatically generated actions (e.g., switching to the next section due to time out). The vast amount of process data gathered during the assessment has opened the door to examining questions that were previously impossible to study. One under-researched area is science assessments. This study shows how relative-risk ratios can be used with extreme response time values and how data can be modeled using clustering and neural networks.

Parallel Session - 4.22 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Elisa Appiani

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417 Using Video Analysis to Explore Pre-Service Primary Teachers' Pedagogical Content Knowledge for Teaching Science

Elisa Appiani

Università degli Studi di Bergamo, Bergamo, Italy

Abstract

Teaching is a complex activity informed by professional knowledge. International surveys and research underline that science teaching is problematic, especially for primary school teachers. Researchers have investigated the nature of pedagogical content knowledge (PCK) mainly for in-service secondary science teachers. Many studies used a text-based approach to elicit the more declarative and static form of teachers' PCK in simplified teaching contexts. Few research papers have considered the knowledge that pre-service teachers activate and use in contexts like real learning classroom situations, especially in the context of initial primary teachers' education. This qualitative study is an attempt to explore and characterize, using a video-based approach, the more situated and dynamic form of PCK underpinning a teacher's in-the-moment pedagogical reasoning investigating one of the bases of teachers' professional knowledge related to enacted PCK, specifically the dimension of knowledge of students' understanding. Among mathematics teacher educators, in fact, a consensus has emerged that effective teaching involves attention to students' thinking. In this perspective, the construct of PCK is closely related to that of teachers' professional vision, which video analysis promotes through the development of those analytical and reflective skills, noticing and reasoning, useful in supporting change in teaching beliefs and practices. The data for this study were collected at the end of a physics education course and fifty-nine pre-service primary teachers attending a degree programme in Primary Education attempted two video-based tasks. The clips were taken from authentic classroom situations recorded by the author to approximate real contexts. The responses were analysed qualitatively and the association between the level of noticing and the connection with student thinking when pre-service primary teachers take in-the-moment decisions has been observed. The implications of the findings stress the need for extended opportunities to learn to notice student scientific thinking and the relationship between teaching and student learning.

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479 Promoting Pre-Service Teachers' Digital-Media Competence - A Development and Evaluation Study

David Weiler[1], Jan-Philipp Burde[1], Rike Große-Heilmann[2], Andreas Lachner[1], Josef Riese[2], Thomas Schubatzky[3]

[1]University of Tübingen, Tübingen, Germany. [2]Paderborn University, Paderborn, Germany. [3]Universität Innsbruck, Innsbruck, Austria

Abstract

The growing importance of digitalization has a major impact on education. Especially since the COVID-19 pandemic, it has become almost impossible to imagine a classroom without digital media. However, using digital media in the classroom effectively to support learning requires subject-specific, digital-media pedagogical content knowledge (PCK). Against this backdrop, a research-based university seminar for pre-service teachers that aims to foster students' digital-media competence was developed and empirically evaluated in a pre-post-design. After a first implementation, the seminar will be iteratively developed using a design-based research approach. The results of the first implementation of the seminar indicate that students' motivation to use digital media in physics lessons strongly increased, while no significant increase in digital-media PCK could be observed. The poster will present the key aspects of the seminar as well as first results of its empirical evaluation.

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767 Investigating the Interplay Between the TPACK and Creativity of Pre-Service Science Teachers

Alper Durukan[1,2], Jale Cakiroglu[1], Sevgi Aydin Gunbatar[2]

[1]Middle East Technical University, Ankara, Turkey. [2]Van Yuzuncu Yil University, Van, Turkey

Abstract

This study examined the relationship between pre-service science teacher knowledge, as represented by the Technological Pedagogical Content Knowledge (TPACK) framework, and teacher creativity. This design-based predictive correlational research included self-rated and objective measurements of TPACK and Creativity. The results indicated a weak positive correlation between self-rated TPACK competencies and self-assessed creativity levels. However, no significant relationship was found between self-rated TPACK and objective measures of Creativity or between self-assessed Creativity and assessments for enacted TPACK. The assessed Creativity partially infers the sophistication of enacted TPACK and Creativity in instructional designs and practices. The study highlighted the need for further research on the relationship between TPACK and Creativity in pre-service science teacher training.

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12 Gamification: Science Pre-Service Teachers' Experiences and Self-Efficacy

Rekha Koul, Rachel Sheffield

Curtin University, Perth, Western Australia, Australia

Abstract

Science teacher educators have a complex role in preparing future science teachers, giving them the content, pedagogical and technological knowledge. New upcoming access to technological resources may assist in increasing the subject content knowledge and self-efficacy of future teachers. The paper outlines research on using a gamified laboratory simulation (Labster), wherein access was given to 45 Science Pre-Service Teachers (S-PSTs) in 3rd year of their Initial Teacher Education for a semester. A mixed method approach was adopted to generate data for this case study, and Makransky and Petersen's (2019) framework was adopted to identify factors in the implementation of Labster including usability, motivation, and perceived use. The data determined that despite the ongoing engagement and interest in games and gamification on the broader community, in an industry worth $9.1 billion in 2020 (MarketsandMarkets, 2020) the perceived engagement and interest did not reflect in responses of all the undergraduate S-PSTs in the study. Many preferred reading textbooks to doing interactive science activities and felt that this resource could be a good learning tool for the students in their secondary science classrooms. The authors of this research postulate that if Labster had key 21st-century skills such as collaboration, communication, creativity and critical thinking embedded into the game then this may be a more engaging and interactive process, which may have engaged the S-PSTs more deeply and provided a more motivating and fulfilling learning experience.

Parallel Session - 4.23 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Moritz Krell

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72 The Role of Digital Media PCK within the Technology Acceptance Model

Thomas Schubatzky[1], Jan-Philipp Burde[2], Rike Große-Heilmann[3], Josef Riese[3], David Weiler[2]

[1]University of Innsbruck, Innsbruck, Austria. [2]University of Tuebingen, Tuebingen, Germany. [3]Paderborn University, Paderborn, Germany

Abstract

Educational technology (ET) plays an increasingly important role in science classrooms and has the potential to support students' learning. However, to harness this potential, science teachers need to implement ET in a purposeful way. One necessary – but not sufficient – prerequisite of a meaningful implementation of ET is the intention to use it in the first place. Previous studies often draw upon ideas of the technology acceptance model (TAM) to investigate factors that influence the intention to use ET in the classroom. Some of these studies also integrated technological pedagogical content knowledge (TPCK) as a predictor of the intention to use digital media. However, most of those studies used self-assessment of TPCK rather than knowledge or performance tests to evaluate relationships within the TAM. Therefore, it is

unclear whether these relationships are due to the actual science teachers' knowledge or rather their self-efficacy to use digital media. Hence, in this study with 148 pre-service physics teachers (PSTs), we evaluated an extended TAM by not using self-assessed TPCK, but digital-media PCK assessed using a proximal knowledge test and the students' self-efficacy to use educational technology in classrooms to address students' conceptions. Results indicate that while the PSTs self-efficacy to use ET and their digital-media PCK are not correlated, they both play a role for the intention to use ET in classrooms. While the PSTs self-efficacy to use ET directly predicts the perceived usefulness, perceived ease of integration and intention to use ET, participants' digital media PCK only predicts the perceived usefulness of ET in classrooms directly and hence plays an indirect role for the intention to use ET. With our contribution, we aim to initiate a discussion about a re-interpretation of TAM-studies using self-assessed TPCK in the light of our results.

299 Tools for Learning – Promoting Reflection for Student Teachers´ Development of PCK

Pernilla Nilsson, Anne-Marie Cederqvist, Mattias Rundberg

Halmstad University, Halmstad, Sweden

Abstract

This paper investigates how the coherent integration of three different tools for reflection during a science methods course can contribute to student teachers´ planning and enactment of science teaching i.e., their development of pedagogical content knowledge (PCK). The Revised Consensus Model (RCM) is used as a theoretical lens for conceptualising links between teaching practice and the development of PCK. The results indicate how the student teachers´ initial PCK (pPCKinput) was manifested into ePCK during the planning and teaching, and further, through reflection, developed to a new and "richer" PCK (pPCKoutput). The three tools encouraged collaborative discussion and reflection about teaching certain big ideas linked to a topic. As such, the case presented in this paper proved to be a coherent way to encourage student teachers to collaborate, reflect and discuss ideas about their teaching practice and their professional development.

578 Perceptions of Teacher Candidates Regarding PCK Levels of Their Instructors

Yasemin Gödek[1], Dilber Polat[2], Volkan Hasan Kaya[3]

[1]Gençlik ve Spor Bakanlığı, Ankara, Turkey. [2]Kırşehir Ahi Evran Üniversitesi, Kırşehir, Turkey. [3]Milli Eğitim Bakanlığı, Ankara, Turkey

Abstract

The concept of "Pedagogical Content Knowledge" (PCK) was first introduced by Shulman (1986) as a "particular form of content knowledge that embodies the aspects of content most germane to teachability" to describe the characteristics that a qualified teacher must have (Shulman, 1987; Gödek, 2002; İzci & Yerdelen Damar, 2016; Saka Öztürk, 2017; İrfan, 2020).

This study was designed to examine the perceptions teacher candidates concerning the PCK levels of their instructors. 463 teacher candidates studying in four different departments in the faculty of education of a state university participated in this research. Survey model has been used. The "Scale for Evaluating Pedagogical Content Knowledge of Instructors" developed by Jang et al. (2009) and adapted into Turkish by Özel et al. (2013) was used as a data collection tool. The scale had two-factors and 28-items, and the Cronbach Alpha reliability coefficient was 0.923. Significant differences were identified according to the departments, and no statistically significant difference was found in terms of gender and class. More than half of the participants evaluated their instructors' PCK levels as "sufficient" and "quite good". Nearly half of the teacher candidates in classroom education, science education and mathematics education departments perceived the PCK levels of the instructors as "inadequate" and "very weak". In addition, the majority of them responded positively to the survey questions including; "My teacher makes connections between the subject and daily life", "My teacher identifies prior knowledge of the students in the lessons" and "My teacher attaches importance to eliminating our misconceptions regarding the content". This research suggests that perceptions of teacher candidates regarding the PCK levels of their instructors should be accepted as valuable indicators of teacher candidates' PCK competencies. It is also suggested that perceptions of teacher candidates regarding the PCK levels of the mentors in the schools should be studied.

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660 Using the PCK Map Approach to Obtain Validity Evidence Based on Response Processes for a Multiple Choice Instrument

Tobias Lieberei, Virginia Deborah Elaine Welter, Moritz Krell

IPN - Leibniz Institute for Science and Mathematics Education, Biology Education, Kiel, Germany

Abstract

As a central part of their professional knowledge, teachers' pedagogical content knowledge (PCK) positively affects the quality of classroom practice and, thus, students learning. To examine the development of PCK during teacher education, measurement instruments of high psychometric quality are required. Along with this, these instruments should be designed to be economically applicable to large samples, which is usually most true for multiple-choice instruments rather than for those with an open-ended response format. However, one difficulty of those instruments is that they do not provide direct information about underlying cognitive processes in item response, although these are a crucial source of validity evidence, especially in knowledge tests. In this study, we examined how the PCK map approach of Park and Chen can be used to obtain validity evidence based on interview-based explanations for choosing answer options in a multiple-choice test to assess PCK about scientific reasoning (PCK_{SR}). Results of n = 10 undergraduate students show that the their explanations for choosing an answer option mainly refer to the PCK components or interconnections indended to capture for each item. At the same time, the participants did not mention PCK components and their interconnections not covered by the test. This illustrates how that the PCK map approach can be used to obtain validity evidence based on response processes. Findings and limitations are

discussed, and recommendations for using the PCK map approach for validity evidence are given.

Parallel Session - 4.24 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Betül Timur

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244 Digital PCK: What Matters?

Elizabeth Mavhunga, Faith Zondi

Wits University, Johannesburg, Gauteng, South Africa

Abstract

Digital-TSPCK is a refined version that arose out of a need to support teachers import their PCK into the digital realm of practice, during the COVID-19 pandemic, and the likely future disruptions. In this paper, we aim to share our findings about the nature of the refined TSPCK construct and what seems to matter when implemented. The study was a qualitative, 2-year longitudinal study located in the 4th year Chemistry Methodology class. The objective of the course is to develop teachers' TSPCK in core topics found in the South African Curriculum, in preparation for their traditional classroom practice. A novel intervention based on digital-TSPCK was implemented for the first time where pre-service teachers (PSTs) learned to develop digital lessons on chemical equilibrium. A total of 6 PSTs were sampled, 3 from the previous year's cohort, exposed to the traditional TSPCK construct, and 3 from the current novel year's cohort, year 2 exposed to digital TSPCK. Data collected entailed submitted teaching videos and stimulated recall interviews. Analysis entailed in-depth qualitative analysis of identified traditional and digital-TSPCK episodes for observation of the nature and structure of the TSPCK component interactions observed. Content analysis was conducted with the interviews. Findings indicate striking epistemological similarities and differences in the nature of the traditional TSPCK and the refined digital-TSPCK construct. Recommendations are made for the implementation of digital-TSPCK in teacher development programmes.

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635 Science Teaching Orientations of Pre-Service Teachers in a Transformative Learning Environment

Duygu Yılmaz Ergül, Mehmet Fatih Taşar

Gazi university, ankara, Turkey

Abstract

It is a common view that beliefs are essential to teachers' technology integration efforts. Our study aims to develop pre-service science teachers' beliefs about the goals and purposes of science teaching, and science teaching and learning in a transformative learning environment.

In the transformative learning intervention, there was a process in which the participants worked together with their critical friends to the activities prepared the components of transformative learning theory. During the 14 weeks, data were collected from interviews, recordings of card-sorting task performances, video-recorded lessons, and participants' lesson plans. The results provide an insight into how the pre-service science teachers developed their beliefs the goals and purposes of science teaching, and science teaching and learning in the transformative learning environment. In this multiple case study we found that the four pre-service science teachers' discourses and their experiences in the classroom were incompatible with their beliefs.

887 Technological Pedagogical Content Knowledge (TPACK) – A Cross-Cultural Comparison Between Germany and Georgia

Amina Zerouali[1], Marika Kapanadze[2], Natia Andguladze[2], Tamar Bregvadze[3], Jenna Koenen[1]

[1]Technical University of Munich, Munich, Germany. [2]Ilia State University, Tbilisi, Georgia. [3]Ilia State University, Tbilisi, Germany

Abstract

The aim of this research is to investigate German and Georgian pre-service science teachers in terms of their technological pedagogical content knowledge (TPACK) and their experiences and attitudes towards the use of information and communication technology (ICT) in educational contexts. To date, most TPACK research has been confined to one country. Few researchers have explored cross-cultural differences within different countries and therefore, educational systems. A self-report questionnaire was used to collect data from n=134 German and n=46 Georgian pre-service science teachers. Independent t-tests and correlation analyses were used to identify differences between the groups. In general, the results indicate significantly higher TPACK scores and more positive attitudes towards ICT among the Georgian students. No significant difference in terms of ICT access and experience was found. To the best of our knowledge, this study is the first to examine the differences between two European countries representing different levels of development.

746 The Effect of Technology Based Concept Tools on Pre-Service Science Teachers' Views About Concept Teaching

Betül Timur[1], Nagihan İmer Çetin[2]

[1]ÇOMU, Çanakkale, Turkey. [2]COMU, Çanakkale, Turkey

Abstract

This research aims to understand the effect of technology based concept tools on pre-service science teachers' views about concept teaching. A total of 108 pre-service science teachers who were studying at different universities in Turkey participated in the study. Qualitative research method was used in this study. The data of the study were collected using pre-and post-questionnaires that includes 11 questions. Data were analysed by content analysis. Analysis

showed that technology assisted concept teaching effected pre-service science teachers' views about concept teaching positively. Based on results, it is recommended that technology based concept tools training increase the motivation and awareness of pre-service teachers' conceptual teaching preferences. We suggest that technology based concept software programs are effective tools for positive effect for pre-service teachers' views about concept teaching.

Parallel Session - 4.25 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Kalliopi Meli

65 Competences of Primary Teacher on Health Education: A Delphi Study

Elena Charro, Esther Charro-Huerga

University of Valladolid, Valladolid, Valladolid, Spain

Abstract

Healthy habits are of great importance to our society, and efforts to promote them should be carried out from primary school. For this purpose, training primary teachers in Health Education is the key. This research identifies the content knowledge, the skills to be acquired, and the strategies to be used for their training using a three-rounds Delphi method. The opinions of a panel of stakeholders to the question "what should primary school teachers know about Health Education?" give a set of six clues in consensus. The main conclusion of this research is that the pre-service teacher should be training as an agent of action in first aids, and not only as a health promoter.

98 Ph.D.-project: Inquiry-Based Science Education in Science Teacher Education

Tonje Tomine Seland Strat

OsloMet – Oslo Metropolitan University, Oslo, Norway

Abstract

Inquiry-based science education (IBSE) has been a key element in science education for the past decades. The aim for this Ph.D.-project is to characterise and further develop the use of IBSE in science teacher education for primary and lower secondary levels through four sub-studies. The studies had different perspectives on the implementation of IBSE, and the goal is to combine results and recommendations from the four studies to obtain a comprehensive view of the phenomenon. The first study was a qualitative systematic review article, with an international perspective on research on IBSE in science teacher education published between

year 2000 and 2019. The aim was to investigate how and with what outcomes IBSE is used in teacher education. The second study had a national perspective, where focus group interviews were conducted with science teacher educators at seven institutions that offer science teacher education in Norway. The aim was to explore how IBSE was implemented in teacher education to prepare student teachers for their professional practice as science teachers. Study 3 and 4 had a local context. Study 3 aimed to investigate the conceptualisations of IBSE of 86 student teachers who participated in a science teacher education course in Norway. Study 4 explored how an open, inquiry-based activity can give student teachers experience with argumentation in science. The results from these four studies will provide new and valuable knowledge for science teacher educators with recommendations for how IBSE could be implemented in their science teacher education courses.

350 Pre-Service Teachers' Understanding and Awareness of Ecological Footprint

Ahmet Burak Şenöz, Şule Elmalı, Elif Atabek-Yiğit, Fatime Balkan-Kıyıcı

Sakarya University, Sakarya, Turkey

Abstract

In today's world, where the issue of sustainability occupies an increasingly important place, it has become critical for individuals to question their consumption habits and lifestyles. Teachers' learning by internalizing the ecological footprint may allow students to develop positive attitudes and behaviors towards the environment starting from primary school. Within the scope of this study, it aimed to determine the understanding and awareness of pre-service classroom teachers about the concept of ecological footprint and to determine their ability to prepare activities for teaching this concept at the primary school level. The study is descriptive research, and qualitative and quantitative data were used. The study group consists of 100 pre-service teachers, 79 female, and 21 males, studying in the Department of Classroom Teaching at a state university in Turkey. The data were collected with the Ecological Footprint Awareness Scale and the Activity Development form developed by the researchers. According to the findings obtained from the research, it was determined that the average scores of the pre-service teachers from the scale were the highest in the energy dimension and the lowest in the food dimension. The findings from the activity development form also support the scores obtained from the scale. While almost all pre-service teachers could identify problems related to energy and water consumption, half of the participants could not identify problems related to food and transportation. In addition, it has been determined that they perceive water consumption as the most important problem that needs to be raised awareness.

687 Achievement in Secondary School Physics as Predictor for University Physics Studies Choice and Acceptance

Kalliopi Meli[1], Dimitris Pantazatos[2], Sofoklis Goulas[3]

[1]University of Patras, Patras, Greece. [2]National Technical University of Athens, Athens, Greece. [3]Brookings, Washington, USA

Abstract

The connection between school achievement and postsecondary education choice has been examined in several contexts. Considering the limited enrollment in many physics departments worldwide, in this study, we attempt to identify how reliable upper secondary school achievement in physics is as a predictor for students' choice of the physics department for university-level studies. Starting from a database of 65,000 students, we examined 19 that were accepted in the two most preferable Greek physics departments. Our findings indicated that the students that opted for a physics department as their first choice (choosers) outperformed their peers that had these departments lower in their lists (nearly-choosers). Based on our results, we discuss to what extent biannual report cards from teachers may have influenced applicants in building a "physics identity" that empowered them towards the national university admission exams.

Parallel Session - 4.26 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Marissa Rollnick

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445 Knowledge Awareness – Content Representation as a Useful Tool

Lukas Mientus, Andreas Borowski

University of Potsdam, Potsdam, Germany

Abstract

For expert planning, teaching or reflecting of physics lessons, the consideration and interconnection of diverse knowledge facets is indispensable. However, these can vary greatly in relation to a specific context. The method of Content Representation (tabular presentation of situational knowledge) can help teachers to present their own pedagogical content knowledge (PCK) in a structured way. In Content Representations, so-called big ideas of a topic are identified individually and then discussed under different aspects depending on the learning group. Teachers rate this procedure as beneficial in order to obtain a clear view of the subject matter and to stimulate awareness of their own profession (personal PCK). In an explorative study, a German-language Content Representation was conducted for the first time with N = 11 physics teachers of different expertise. Differences and similarities between the comparison

groups of physics pre- and in-service teachers and physics education researchers were demonstrated. In a further step, the compatibility of the subject-oriented method with the educational standards was compared, since the area of tension between competence and content orientation seems to be particularly high here. The presentation gives a well-founded insight into the Content Representations and clarifies the potential of the method for upcoming usage and research.

1268 Supporting Teachers in the Design and Enactment of Socioscientific Issue and Model-Based Learning (SIMBL): A Multiple-Case Study

Benzegul Durak[1], Mustafa Sami Topçu[2]

[1]Düzce University, Düzce, Turkey. [2]Yildiz Technical University, İstanbul, Turkey

Abstract

The present study propose a professional development (PD) program for middle school science teachers and explored their teaching practices on Socioscientific Issues and Model-Based Learning (SIMBL) framework. The PD program consists of three phases: learning with SIMBL, teaching with SIMBL and curriculum unit design with SIMBL. In the first phase, the science teachers participated in a SIMBL unit presented by the researchers. In the second phase, the teachers explored the SSI, SSI-based teaching framework scientific models, modelling, model-based learning and lastly SIMBL framework. In the third phase, the teachers designed SIMBL unit plans. After the PD program, the science teachers implemented their SIMBL units in their own classrooms. The data sources are interviews including one interview before the PD program and one interview at the end of the PD program, and a post-implementation interview. Also, field notes of the PD program and the SIMBL curriculum units are secondary data sources. The data were analysed using the Interconnected Model of Professional Growth theoretical framework to explore the teachers' enactment of SSI and modeling, their interactions with the researchers and colleagues during PD, their beliefs about teaching and learning and their perception of the outcomes of SIMBL framework.

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723 Teacher Professional Competencies for Enacting Model-Based Inquiry in Science Classrooms: A Scoping Review

Lihua Xu[1], Kennedy Chan[2], Suchi Fang[3], Linda Hobbs[1]

[1]Deakin University, Geelong, Victoria, Australia. [2]The University of Hong Kong, Hong Kong, Hong Kong. [3]National Taiwan Normal University, Taipei, Taiwan

Abstract

The emphasis on engaging students' in modeling practices and modeling-based reasoning requires a fundamental shift in how teachers think about models and enact instruction that engage students in modeling practices in classrooms. The purpose of this study is to map literature that focuses on aspects of teacher professional competence for model-based teaching (MBT) with an attempt to propose a framework that can be used to describe and guide

the development of teacher professional competence. Drawing on a scoping review methodology, this paper identifies and critically reviews the findings of empirical studies published from 2015 to 2022. This review is guided by the following question: What professional competencies science teachers need to develop for enacting MBT effectively? Preliminary analysis of the 48 articles reveals a disconnect between studies of teacher dispositions and teacher instructional practices in classrooms. This review highlights a strong need for an integrated competence framework that articulates what teachers need to know and do in order to enact MBT effectively in classrooms.

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999 An Out-of-Field Teacher's Pedagogical Reasoning While Solving a Two-Body Problem in Mechanics

Marissa Rollnick[1,2], Rene Toerien[3], Ernest Mazibe[4]

[1]Wits University, Johannesburg, Gauteng, South Africa. [2]University of Pretoria, Pretoria, Gauteng, South Africa. [3]Rondebosch Boys High School, Cape Town, Western Cape, South Africa. [4]University of South Africa, Pretoria, Gauteng, South Africa

Abstract

Solving complex problems involving Newtons laws of motion are well known for being challenging to both teachers and learners. This challenge is even greater for out of field physical science teachers who may be better versed in chemistry, rather than physics. In this study I tackled the solution of a problem on Newton's laws of motion to teach grade 12 students. The aim of the study was to illuminate the teaching strategies that unfolded, and how my pedagogical reasoning assisted in the process of developing those strategies. The research took the form of a self-study, where critical friends assisted me to think through the concepts and how I would teach them. As I interacted with my critical friends, shortcomings in my content knowledge emerged as I struggled with the conceptual challenges associated with the problem. Reflections such as these are useful to other teachers as they will help teachers rethink their teaching approaches and address possible shortcomings in their content knowledge.

Parallel Session - 4.27 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Özlem Balkan

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572 Uncovering Experienced Science Teachers' Pedagogical Content Knowledge (PCK) Concerning Respiratory and Urinary System

Elif Kınık Akman, Ceren Öztekin

Middle East Technical University (METU), Ankara, Turkey

Abstract

A case study was conducted to explore experienced science teachers' pedagogical content knowledge (PCK) regarding human body systems (HBS), particularly in the respiratory and urinary systems. Semi-structured pre-interviews including Content Representation (CoRe) questions, classroom observations, teachers' documents, and post-interview were used to obtain data from two experienced science teachers. Findings show that participants' central goals were subject matter goals and schooling goals. They were aware of the objectives, the place of the HBS in the science curriculum, and the requirements of students' learning. Teachers used several topic-specific instructional strategies (i.e., analogies, drawing, modeling) while teaching respiratory and urinary systems. When assessing students' content understanding, they preferred traditional assessment methods and benefited from both formative and summative assessments.

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715 Analyzing an Effective In-Service Science Teacher Professional Development Model Through the Lens of Professional Development Principles and Mechanisms: Developer and Teacher Educator Perspectives

Kārlis Greitāns, Dace Namsone

University of Latvia, Rīga, Latvia

Abstract

Recent studies identify the "funnel" effect in science teacher professional development – not all the professional development activities intended by the designers are carried out by teacher educators, also not all the ideas that teacher educators are promoting reach the science teachers. In the present paper the authors attempt to look in details about this phenomena and trough qualitative phenomenological research attempt to uncover the reasons why teacher educators change the intended design of a science teacher professional development model. This study takes a novel approach to science teacher professional development research – the teacher professional development model (previously developed by authors) is being analyzed from the lens of teacher professional development principles and mechanisms. The semi-structured interview analysis indicate that teacher educators make minor changes in comparison to intended mechanisms; the abandonment of professional development mechanism is reasoned by lack of resources, negative connotation, and the unequal value of the mechanisms from teacher educator perspective.

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923 Different Types of Vocabulary, a Tool for Improving Science Talks in School

Sonja Heinrich, Anna-Vera Meidell Sigsgaard, Ditte Marie Pagaard, Dorte Maiken Lohse, Suzanne Schjøtt

University College Copenhagen, Copenhagen, Denmark

Abstract

The paper takes its point of departure in professional development of science teachers and their challenges in supporting students in developing appropriate academic discourse in their science classes. The work reported on acts as an extension of an educational research and development project in progress, "Semantic Waves & Linguistic Snails", the aim of which is to make science lessons in the Danish middle-school (grades 4-6) more accessible to all students by increasing science-teachers' awareness of the linguistic challenges second-language learners in particular (can) encounter in science lessons and materials. In this paper we highlight how findings from the project translate to and are implemented in a professional development science module and related professional development coaching course with a 4th grade science teacher. The aim of this paper is to demonstrate how explicitly working with different types of vocabulary in science, including the general academic vocabulary, can be used as a tool for developing metalinguistic awareness for both teachers and students.

1202 Predictors for Self-Efficacy of Science Teachers in Turkey

Özlem Balkan

Bahçeşehir University, İstanbul, İstanbul, Turkey

Abstract

This study focused on the self-efficacy of science teachers in Turkey based on the secondary analysis of TALIS 2018 data. A multiple linear regression analysis was conducted in order to investigate whether the variables of professional collaboration, satisfaction with autonomy, perceived disciplinary climate, workplace well-being and stress predicted the Turkish science teachers' self-efficacy level. Participants of the study included teachers from Turkey that indicated science as the primary subject area they taught. The results indicated that a there was a statistically significant relationship of the variables of professional collaboration, satisfaction with autonomy, perceived disciplinary climate, workplace well-being and stress with the Turkish science teachers' self-efficacy level. Among the four variables, satisfaction with autonomy had strongest predictive relationship to the self-efficacy of science teachers in Turkey, followed by professional collaboration, perceived disciplinary climate and workplace well-being and stress.

Parallel Session - 4.28 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Engin Karahan

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60 Developing Character Types for Dealing with Scientific Questions and Problems in Pre-School Age

Maria Sophie Schäfers, Claas Wegner

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Abstract

Over the past years, the importance and relevance of science education and the promotion of scientific competences in preschool age have increased continuously (e.g., Lück, 2013; OECD, 2018). This is not least due to the correlations between pre-school science education and later school success in science subjects, which have been found in various studies (e.g., Claessens & Engel, 2013; Guo et al., 2015; Morgan et al., 2016). Particularly in connection with the prevailing shortage of skilled workers in occupations in the natural sciences (Anger et al., 2022), the promotion of talented and interested students seems to be necessary in order to motivate them for a career in this sector in the long term (anonymized). Leuchter and Saalbach (2014) stress that it is important to determine the children's prior knowledge in order to be able to offer appropriate support. Thus, a scientific talent test was developed to identify the children's competences in science (anonymized). Utilizing the test showed that not only the children's performances are important for measuring scientific competences, but also their observed behavior during the tests (anonymized). To this end, an observation sheet was developed on the theoretical basis of the Leuven Scale (Laevers, 2009; MacRae & Jones, 2020). It systematically records the children's facial expressions, gestures, posture and interaction as well as their active engagement and emotional well-being during the test. In a qualitative study, data from $N = 202$ observation sheets were systematically analyzed by five coders. The resulting typology shows the different types of behavior when dealing with scientific problems and questions at pre-school age. Based on the analyzed behavioral characteristics, promotional offers are now developed which are tailored to the characteristic traits of the children. This in turn could mean that such promotion offers could possibly more successful.

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198 Examining the Individual Characteristics of Korean Elementary School Students' at the Phase of Interest Development

Yoon-Sung Choi

Seoul National University, Seoul, Republic of

Abstract

The purpose of this study was to explore the individual characteristics of Korean elementary school students at the phase of interest development using Process-Person-Context-Time (PPCT) model. Three hundred and thirty elementary school students in Seoul were surveyed three-times at 6-month intervals. Four of these students were chosen as case studies. Students wrote photo-journals for 12 weeks and met with the researcher every two weeks for a total of six meetings to participate in semi-structured interviews. The individual characteristics of the students were analysed using ecological system theory and the PPCT model. The results

showed that not only did students participate in experiments and write activities reading science magazines and books in the photo-journal, but there might be ' a school-teacher' in the person element. Students who had higher interest, showed a tendency to revitalize process and were independent. This study organized students' individual characteristics at the four phases of interest development to develop theoretical background. This study may be expected to have academic significance to show the personal characteristics of Korean students at the phase of interest development and can be used for international comparative research related to science interest in the future.

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217 A University-School Collaboration for Designing a School-Based STEM Initiative

Engin Karahan[1], Ahmet Oğuz Akçay[2], Mehmet Arif Bozan[3]

[1]Middle East Technical University, Ankara, Turkey. [2]Eskişehir Osmangazi University, Eskişehir, Turkey. [3]Istanbul Aydın University, Istanbul, Turkey

Abstract

Education policymakers continue to argue over the best ways to incorporate science, technology, engineering, and mathematics (STEM) subjects into classroom instruction. This research provides insight into the effects of STEM activities implemented in schools with university-school partnerships on both students and teachers. The STEM initiatives in this study were also meant to foster a positive school climate. The study was conducted as an intervention in the classroom with a focus on science, technology, engineering, and math (STEM) instruction. This study followed a collaborative action research design as a response. The research was conducted at a public primary school serving students from middle-class families. A total of 450 pupils from the school's third and fourth grades took part in the research. Twelve third and fourth-grade teachers were also part of the investigation. Data gathered through interviews and questionnaires were analyzed using content analysis. Students' perspectives on the effects of STEM education in the classroom are highlighted, with particular attention paid to the ways in which students' motivation to learn and the value they place on STEM-based learning processes. Teachers' views revealed the effects of STEM activities on students' motivation and participation in the learning process, as well as the effects on teachers' professional growth and the obstacles encountered in implementing STEM activities. Results from this research showed the transition of the school's culture toward a STEM focus and the growth of students' and teachers' STEM practices while at school. Therefore, the study is of particular relevance in illustrating the applicability of the STEM initiative.

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589 The Approach of the Cerrado Bioregion in Brazilian Public Schools: An Analysis of Textbooks, Curriculum and Teachers' Perceptions

Ana Julia Pedreira, Samuel Molina Schnorr

University of, Brasilia, DF, Brazil

Abstract

The Cerrado, a big bioregion in Latin America, has great ecological relevance. In addition to being the cradle of major hydrographic basins in South America, it encompasses the most biodiverse savannah of the world. This theme is dealt with in Brazilian schools so that students can get to know this bioregion and thus understand the importance of its preservation. Since it is the science teachers' role to help students with this understanding, under the development of the content of ecology it is necessary to include this content in the initial and continued education processes of teachers. Another way to ensure this subject is approached in the classroom is to include it in the curriculum documents of Brazilian schools and in the textbooks distributed to public schools by the National Programme for Books and Teaching Materials (PNLD, in Portuguese). Given the above, the objective of this research was to verify whether the Cerrado theme has been included in curriculum documents and textbooks in Brazil and if there is a connection about how this theme is approached between these materials. For this, we analysed the Common National Curricular Base (BNCC, in Portuguese), 42 textbooks from the PNLD 2021, high school textbooks and the perceptions of 43 science teachers about the presence of this topic on these documents. Our results show that the theme is mostly absent from these materials. The tendency then is to affirm that there is a relationship of absence, which can be worrying since by not bringing this discussion to the classroom, this theme may be put aside, not being awakened in the students, who go through school without often having the perception of how important it is to preserve this biome.

Parallel Session - 4.29 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Melinda Kirk

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995 An Analysis of Knowledge Domains and Cognitive Levels in Questioning of Taiwanese Science Textbooks

Shih-Wen Chen[1], Chih-Hsiung KU[2]

[1]National Academy for Educational Research, Taipei, Taiwan. [2]National Dong-Hwa University, Hualien, Taiwan

Abstract

Based on the framework of Revised Bloom's Taxonomy proposed by Anderson and Krathwohl (2001), the present study aims to explore the knowledge dimensions and cognitive levels of questioning within science textbooks in Taiwanese junior high schools. The results show that most of the questions in scientific textbooks significantly refer to factual and conceptual knowledge domains as well as low-level cognitive questions. It indicates the questions in science textbooks mainly guide students to learn about factual and conceptual knowledge and

offer low-level cognitive questions which would be difficult to trigger students' high-level cognitive thinking. Some suggestions finally are provided for textbooks writers and science teachers to rethink how to improve the questioning quality in scientific textbooks for better science learning.

996 Model-Based Inquiry to Improve Learning About Human Prenatal Development in Secondary School Students

Jose Manuel Sánchez Robles[1], Remedios Pallarés Martínez[1], María Martínez Chico[1], Lucía Torres Muros[2], María Rut Jiménez-Liso[1]

[1]University of Almería, Almería, Spain. [2]University of Granada, Granada, Spain

Abstract

Despite the recognized importance of embryonic development as a key teaching-learning content in science teaching, the results of research on the conceptions and learning difficulties of students, as well as on specific proposals for teaching these contents, are scarce. In this paper, as a part of a Design-Based Research, the design and implementation of an instructional sequence about prenatal human development for Secondary school students through scientific practices are presented. After expressing their personal ideas using different ways to express them, a set of activities are included to promote the construction of evidence-based knowledge. The learning progressions achieved by the group reveal an evolution from their initial ideas mainly based on misconceptions, towards more sophisticated models of the human prenatal development, reaching 84% students the most sophisticated one. Students' misconceptions expressed during sequence development are described, highlighting those related to the absence of gametes and cell division or the lack of utility of placenta-umbilical cord system in their initial models. This work contributes to the scarce research on learning and teaching of human prenatal development.

1047 Enhancement of Students' Science Process Skills Through Inquiry-Based Instruction

Muserref Busra Yagli[1], Jale Cakiroglu[1], Meryem Beklioglu[2]

[1]METU Faculty of Education, Mathematics and Science Education Department, Ankara, Turkey. [2]METU Department of Biological Sciences, Limnology Laboratory, Ankara, Turkey

Abstract

The aim of this research was to explore the effect of inquiry-based instruction on middle school students' science process skills. For this purpose, single-subject experimental research with a pretest and posttest design was utilized. The sample of the study included fifty-two students from seventh grade in a middle school in Turkey. Lessons were developed according to an inquiry-based learning approach on the topic of the lake ecosystem and applied by science teachers of their own. The students experienced in-class and out-of-classroom inquiry activities as well as seminars given to students by scientists. Data were collected by using Science Process

Skills Test that consists of both basic and integrated science process skills. The results of paired sample t-test indicated that students' science process skills, particularly basic science process skills were significantly improved by following the inquiry-based lessons.

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603 Semiotics Enabled Critical Thinking in a Community of Inquiry Primary Science Classroom

Melinda Kirk[1], Russell Tytler[2], Peta White[1], Joseph Ferguson[1]

[1]Deakin University, Melbourne, Victoria, Australia. [2]Deakin University, Melbourne, Victria, Australia

Abstract

Critical thinking is recognised as an important aspect of education, including in STEM, associated with the need to focus on innovation and solutions. This is reflected in the recent education policy and research shift in focus from conceptual understanding, or content, to scientific practices, inquiry, and real-world experiences in science. How this can be meaningfully enacted in the primary science classroom however is less understood, and a goal of this design-based research. This research is focused on critical thinking in science, as enabled through a classroom 'community of inquiry'(COI). Critical thinking: argumentation, reasoning, and problem solving are identified as socially and semiotically supported. This paper reports on a Year 6 interdisciplinary (Science and mathematics), guided inquiry learning design on microorganisms. An authentic inquiry, investigating microbial load in the air in student selected different locations of the school resulted in the identification of a 'real problem', high microbial load in the school Lost Property Box (LPB). Students' pursuit of science-based solutions resulted in the actioning of the classroom as a COI. Collaborative argumentation led to the development of revised LPB procedures that were adopted by the school. A pragmatist semiotics analysis, with specific attention to student critical thinking within a COI has been adopted to examine the role of scientific-multimodal signs in enabling generative critical thinking in primary science.

Parallel Session - 4.30 (Oral Presentations)

14:00 - 15:30 Tuesday, 29th August, 2023

Chair: Carmella Shahab

Schedule for Aug 28-30 Examination of Modern Physics Textbooks in Terms of the Teaching of Quantization

Nilüfer Didiş Körhasan

Zonguldak Bülent Ecevit University, Zonguldak, Turkey

Abstract

Previous research showed that students had mainly unscientific mental models about quantization and their mental models were influenced by the instructional elements such as the manner of teaching, order of the topics and familiarity with concepts, and peers. Considering textbook as one of the external elements interacted with students in and out of the class, two undergraduate level modern physics textbooks were examined in terms of the teaching of the quantization of physical observables. Content analysis conducted to the textbooks for the explanation of quantization and the methodologies used for the explanation of quantization such as stress on quantization and explicit/implicit use, distribution of representations for quantization, relation with the nature of science and history of science issues etc. While this study presents the similarities and differences in the textbooks, it also indicates the important issues in textbooks used for the teaching of quantization.

1054 How Recognition as a "Physics Person" Predicts Motivation for Physics

Anders Lauvland, Maria Vetleseter Bøe

University of Oslo, Oslo, Norway

Abstract

To study physics in higher education is commonly perceived as a challenging endeavor. In order to counteract underrepresentation and retention issues in physics, it is important to study student motivation. Physics identity has risen as a much studied construct in recent years, recognizing oneself as a "physics person" appears to be indicative for persistence in physics. In this work we integrate a "physics person" construct to expectancy value theory as a mediator for motivation. The findings indicate that there are notable gender differences in our physics person construct and in several motivational factors from expectancy value theory. When controlling for gender, we find that students who view themselves as a physics person tend to be more interested, have higher expectation for success, and perceive physics as more useful for future pursuits of job and studies. Therefore, it seems that one way a physics identity increases persistence in physics ,is through increasing the value of studying physics for the students and their expectation of success in it. However, the physics person construct does not predict well the perceived cost of studying physics. Hence, having a well-developed physics identity does not appear to enable students to see the subject as less costly.

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502 Learning About Sound in Initial Teacher Training: Evaluationand Redesign of a Teaching-Learning Sequence

Ruiz-Gonzalez Aritz[1], Arantza Rico[1], Jenaro Guisasola[2]

[1]Faculty of Education and Sport. University of the Basque Country, UPV/EHU, Vitoria-Gasteiz, Spain. [2]College Of Dual Engineering. Institute Of Machine Tools Campus (IMH), Elgoibar, Spain

Abstract

One of the fundamental elements in Design-Based Research (DBR) when developing teaching-learning sequences (TLS) is making explicit the design tools used throughout the whole process, from the epistemological content analysis and the identification of learning demands in the design phase to those tools used in the evaluation and redesign phases. This paper focus on the evaluation phase of a TLS about sound and presents an iterative methodology that allows taking empirically-based decisions for the refinement and further implementations of our TLS. This validation occurs in two dimensions: the analysis of the TLS quality and the learning achievement. In this paper, we present results regarding the assessment of student learning in relation to phenomenological aspects of sound, such as its vibratory nature and its propagation.

846 Perceptions of Critical Thinking and its Prevalence in Science and Engineering Education

Carmella Shahab[1,2], Miri Barak[1]

[1]Technion Israel Institute of Technology, Haifa, Israel. [2]The Max Stern Yezreel Valley College, Jezreel Valley, Israel

Abstract

Educating scientists and engineers to be critical thinkers is viewed as a core competency essential for university graduates to successfully compete in the 21st century global economy. However, much obscurity remains regarding how to integrate it in science and engineering education. The goal of the current study was to analyze, from a sociocultural perspective, the way critical thinking (CT) is perceived and experienced by different stakeholders in a research university in Israel and its international branch campus in China. In order to address the research goal, the study applied an integrated dual-analytic approach, where data was collected via semi-structured interviews. The findings indicate that all of the instructors and most of the Chinese students (82%) stated that they are familiar with CT whereas few of the Israeli students (35%) asserted familiarity with the concept. Nonetheless, even those who were familiar with the concept, provided a partial description, or included misconceptions regarding the notion. The findings also show that many instructors and students have incorporated or experienced activities which promote CT to some extent, with students mainly involved in analysis processes, and less by means of self-regulation activities. Overall, it is apparent that the Chinese students claim to have had more experience with all of the CT skills than the Israeli students and equivalent or more encounters than the instructors.

Parallel Session - 5.1 (Posters)

16:00 - 17:30 Tuesday, 29th August, 2023

Chair: Ragnhild Lyngved Staberg

1253 Investigation of the Consistency of Learning Outcome and Evaluation in Science Curriculum

Feride Eda Öztürk

Milli Eğitim Bakanlığı, Ankara, Turkey

Abstract

The aim of this study is to investigate consistency of the learning outcomes with the evaluation questions for the subject of "measuring force" in the 5th grade. This study was designed as a qualitative case study. Document analysis was used as the data collection technique. The Ministry of National Education (MNE) 5th grade science textbook, MNE learning outcomes/comprehension tests and MNE skill-based tests were investigated in the study. It was observed that the evaluation questions in these documents were directed towards measuring the learning outcomes in mathematics in addition to the learning outcomes in measurement of force. Therefore, it was concluded that there is an inconsistency between the learning outcomes in the curriculum and the evaluation questions in the textbook and the other documents that were investigated. The success of the students in science is negatively affected by this inconsistency. It is suggested that the learning outcomes directly related to the mathematics should be eliminated from the evaluation questions of science subjects. The learning outcomes of the science should be handled in parallel with the mathematics curriculum, and the learning outcomes should be made more understandable for science teachers in order to establish an interdisciplinary relationship between science and mathematics. Eliminating the inconsistencies between the elements of the curriculum (learning outcomes, content, teaching situations, evaluation) and considering these elements as a whole will improve science education.

1106 Elaboration of a Teaching-Learning Sequence Proposal to Approach Industry 4.0 Concepts in Science Classes

Cleiton Maciel[1,2], Maurício Pietrocola[1]

[1]Universidade de São Paulo, São Paulo, SP, Brazil. [2]Instituto Federal de Educação, Ciência e Tecnologia de São Paulo, Itaquaquecetuba, SP, Brazil

Abstract

The history of humanity has witnessed a unique moment, which is the development of a new industrial model known as Industry 4.0, in reference to the fourth industrial revolution. The professionals inserted in this new arrangement will need to have specific skills, such as being

able to solve complex problems, mastering Information and Communication Technologies (ICT), presenting critical and creative thinking, among others. In addition to the economic impacts, this new industrial paradigm also has a strong impact on the educational area, as the role of training qualified professionals for these future demands will rest on the school. Considering that professional and technological education will be one of the main modalities to act together with the formation of this professional profile, this work presents a proposal for a teaching-learning sequence, which aims to articulate the concepts of Industry 4.0 and Physics with the other areas of a technical course integrated into secondary education in order to contribute to the comprehensive training of the target audience at this level of education. For this, the design-based research (DBR) methodology will be adopted, which will have polytechnics as one of the principles that will guide the elaboration of this educational intervention.

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936 Can Chemistry Textbooks Be Used for Model-Based Learning?

Alba Cortés-Morales, Ainoa Marzábal

Pontificia Universidad Católica de Chile, Santiago, Metropolitana, Chile

Abstract

According to the recent reform of the Chilean science curriculum, school science education should prepare students to be critical thinkers and citizens who can participate in social discussions and decision-making. This curricular change means that ninth and tenth grades have three science classes that tackle contents differently than past reforms, and eleventh and twelfth grades have a new subject called "science for citizenship." As the textbooks are accessible to every school that receives funding from the government every year, these are resources that every student can use and are a starting point for teachers planning. The Ministry of Education has changed the unit questions in chemistry textbooks, allowing students to talk and evaluate their initial ideas using different phenomena. The activities of the textbooks have open questions, usually contextualized, that aim to help students learn the subjects with situations closer to their experiences and challenge them to think about how these situations can be explained. Because of the proposed approach to learning science and the activities in the textbook, we believe it may be possible for teachers to use the Chilean chemistry textbook for model-based learning, either as a resource from which to begin lesson planning or as a modelling teaching and learning sequence. To make this judgment, we characterized the chemistry textbooks aimed at ninth and tenth-grade students using characteristics found in the literature for modelling teaching and learning sequences. Our analysis highlights how some units of the textbook are more conducive to modelling and the need to recognize that teacher management influence the modelling process. On the other hand, we acknowledge that the activities have a modelling potential that could increase or decrease depending on classroom interactions.

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909 Integration of a Data Science Learning Progression in a Biomedical Sciences Bachelor's Program

Annelies Pieterman-Bos, John Meeuwsen, Marc van Mil

UMC Utrecht, Utrecht University, Utrecht, Netherlands

Abstract

Existing data science education in curricula for biomedical scientists need to be revised to address the challenges of the increasing size and complexity of data. We designed and studied a data science learning progression for a biomedical sciences bachelor program, aimed at increasing retention and transfer of data science understanding and skills. We used a predominantly qualitative, contextualist research design to explain the effects of the educational design on students' and teachers' behaviour and perceptions. We used course evaluations, student and teacher focus groups, and a questionnaire. Through reflexive thematic analysis of these data, we formulated conjectures about how educational design features engender learning mechanisms and conjectures about how these learning mechanisms support retention and transfer (resulting in a conjecture map). Important features are integration of data science content with domain specific content, appropriate scaffolding, repetition over long time periods, and reducing the number of statistical tests to be learnt. The conjecture map provides a theoretical frame to describe and explain how specific design features support data science learning and can assist others who aim to implement a data science learning trajectory.

815 Comparing the Effects of Two Teaching Interventions About Light Diffraction on Students' Adoption of the Wave Model of Light

Danilo Catena[1], Marisa Michelini[1], Lorenzo Santi[1], Alberto Stefanel[1], Italo Testa[2]

[1]University of Udine, Udine, Friuli-Venezia Giulia, Italy. [2]University of Naples ''Federico II'', Napoli, Campania, Italy

Abstract

This study illustrates two different approaches for teaching interventions focused on light diffraction, aimed at familiarizing students about the main features of the wave model of light, in comparison to the ray model. The first approach begins with a lab experiment and guides the students to the key ideas of light diffraction, adopting an inquiry-based approach. In the second one, the wave model is presented before the experimental activity. A common open-ended post-test is proposed to evaluate the effectiveness of the two approaches in term of awareness of the features of the diffraction phenomenon and its interpretation in terms of the wave model of light, analyzing students' responses through a priori categorization. The results will help us to develop a Teaching-Learning Sequence (TLS) on light diffraction, with the aim of overcoming students' difficulties in understanding diffraction phenomenon and making them aware of the main features of the wave model of light. Data are currently being collected and

preliminary results will be presented at the conference.

791 Playing With Science: A Review of Scientific Board Games

Laura Martín-Ferrer[1], Ferran Renalias-Zueras[2], Jordi Lorente-Servitja[2]

[1]Universitat de Vic-Universitat Central de Catalunya, Vic, Barcelona, Spain. [2]El CAE, formació i serveis socioculturals, Manresa, Barcelona, Spain

Abstract

Gaming promotes the development of skills, attitudes, and values that are useful for scientific thinking or practice (Morris et al., 2013). However, there is still a lack of research that deeply reflects on which kinds of games are appropriate and how to implement them in an innovative approach to avoid perpetuating obsolete methodologies. Although exists a large battery of board games on science themes, teachers must be able to critically select those that will be suitable for their pedagogical goals. This research provides a review of 104 science board games with the objective of identifying valuable tools for science learning. According to the results, there are 4 groups of games with higher and lower fostering of scientific practice and scientific literacy, which shows that not all board games have the same value in science education.

327 Science Instruction in Hospital: Task Analysis

Şahika YILDIZ[1], Hanife Can ŞEN[2]

[1]Ministery of Education, Antalya, Turkey. [2]Adnan Menderes University, Aydın, Turkey

Abstract

This study deals with the task analysis phase of the instructional design developed for 5th grade Measurement of Force and Friction unit for hospitalized students. In this study, the stages of the task analysis were explained through the sample acquisition and its contribution to the next processes of the instructional design were discussed.

287 A Learning Method for Projectile Motion through Archery in Turkish Cultural Heritage

Seda Çekiç Toroslu

Etimesgut BİLSEM, Ankara, Turkey

Abstract

The aim of this research is introduce the plans of STEM education to teach projectile motion by using Turkish archery as a part of Turkish cultural heritage. STEM education plans are based on 7E learning model and problem based approach. These plans were applied for four weeks to 20 gifted students who educated in Science and Art Education Center (BILSEM) in Turkey. Science and Art Education Centers are a kind of school which gifted and talent students are

educated. Lessons in Science and Art Education Centers are mostly taken through STEM approach by students. Students' feedback were taken about these education.

25 Online Biology Course is Equally Effective as In-Person Course at Promoting Student Performance and Perceptions of Learning Gains

Kevin Bonney

New York University, New York, NY, USA

Abstract

Online courses were slowly increasing in popularity in higher education for four decades prior to the rapid, widespread, and highly controversial global adoption of online learning in 2020 due to the COVID-19 pandemic. One problem inherent to online learning is that additional research is needed to elucidate the overall effectiveness of online courses and to determine which pedagogical approaches are most effective in online settings. The study reported here tested the hypothesis that an online version of an undergraduate biology course can promote student performance and perceptions of learning gains equally well as an in-person offering of the same class, when both are taught using the flipped classroom teaching method. This study also surveyed students to determine which course components are perceived as being equally or more effective at promoting learning online compared to an in-person class. Results indicate that there was no significant difference in performance on summative assessments, final course grades, or perception of learning gains among students in each course modality. Further analysis revealed that some course components, such as completing virtual labs, were perceived as more effective in the online version of the course, while others, such as participating in class discussions, were perceived as more effective in person. A subset of course components were ranked as similarly effective in both versions of the course. Therefore, this study supports the conclusion that offering undergraduate science courses online can be as effective as providing them in person. Future studies are warranted to determine if these findings apply more broadly to other educational disciplines and settings.

6 The Design of E-Learning in (STEM) Education

Dave van Breukelen, Maurice Smeets

Fontys University of Applied Sciences, Sittard, Limburg, Netherlands

Abstract

The Netherlands is currently facing a shortage of STEM employees. This is partly caused by an increasing pupils' lack of interest and performance in STEM (secondary education), which results in a large number of non-STEM-related study and career choices. An important reason for this is the often traditional way of monodisciplinary, theoretical science teaching. To address this, the approaches of inquiry- and design-based learning (IBL, DBL) can be used, offered through interactive, online learning tools and environments. In other words, pupils are activated through inquiry and design activities where technology is used to replace (parts of) face-to-face

education (e-learning). Of course, e-learning is also important to facilitate time- and place-independent learning. To explore this, two studies have the main focus. First, studying the didactic and pedagogical design of e-learning because much has been written about e-learning, but little is known about crucial design principles. Second, using insights to design IBL and DBL activities. The first study will be the focus of this abstract and had the following research question: What is known, from empirical research, about didactic and pedagogical strategies, methods, and techniques concerning e-learning design? Based on a systematic literature review, 42 studies were included (out of 1857 hits). Open and axial coding was used for analysis. Two continuums were distinguished as important for e-learning: active and authentic learning continuum. Those continuums appear to be useful to give a visual representation of included studies, which resulted in four clusters with (slightly) different properties. These properties mainly vary in the authenticity level and student-centredness, but in general e-learning initiatives should be authentic and self-regulating. Analysis revealed four crucial aspects to achieve this: (1) content scaffolding, (2) process scaffolding, (3) peer-to-peer learning, and (4) formative strategies. To help practitioners in realising e-learning design, each aspect is provided with concrete design suggestions.

Parallel Session - 5.2 (Posters)

16:00 - 17:30 Tuesday, 29th August, 2023

Chair: Digna Couso

1218 Examination of Secondary School Students' Conceptual Developments on Geoscience Topics With Geoscience Education

Güneş Keskin[1], Hikmet Sürmeli[2]

[1]TEK Kampus Okulları, Hatay, Turkey. [2]Mersin University, Mersin, Turkey

Abstract

The aim of this study is to examine the secondary school students' conceptual development of geoscience topics. To reach this aim geoscience education containing geoscience topics was applied to the 7th grade students. Geoscience topics considered in this education were classified as; the structure and formation of the Earth, layers of the Earth, minerals and rocks, fossils, soil, plate tectonics, geological time and destructive natural events (earthquake, flood, hurricane, volcanic eruption). Case study, one of the qualitative research methods was used in this study. Lesson plans prepared in accordance with the inquiry-based teaching model and including activities were prepared by the researcher and applied to the study group for 8 weeks. The study group, 7th grade students in a public school, was determined by purposive sampling method. For data collection, before geoscience education program, students were asked to prepared "Science writing heuristics" in order to fill it what they learned during activities. Worksheets and evaluation forms were also applied to the students after each lesson

to get information about their conceptual development on geoscience topics and also semi-structured interviews were conducted at the end of the program in order to learn students' opinions on geoscience education program. The data obtained in the study were analyzed and the results were interpreted.

1089 Chemical Kinetics: The Use of Investigative Experiments in the Search for Meaningful Learning

Daniele Raupp[1], José Gregório[2], Águeda de Aguiar[1]

[1]Federal University of Rio Grande do Sul, Porto Alegre, RS, Brazil. [2]Federal University of Rio Grande do Sul, Porto alegre, RS, Brazil

Abstract

Learning chemical kinetics is crucial for understanding and predicting how chemical reactions will occur under different conditions, such as temperatures or concentrations. This understanding can beapplied to design and optimize chemical processes, including the production of industrial chemicals, drugs, and materials for thedevelopment of new and more efficient catalysts, as well as in the development of new and useful chemical reactions. Additionally, it is essential for understanding many natural and everyday phenomena, for example rusting of iron, cooking and food conservation, air pollution and climate change. Nevertheless, there are several challenges when learning about chemical kinetics, such as understanding the mathematical concepts and equations that are used to describe and analyse chemical reactions. These concepts can be complex and may require a strong background in mathematics. This content in Brazilians High School is often taught with the mere application of formulas. With the objective of developing this contentand in order to overcome these difficulties, this work aims to present the preliminary results of a case study applying a teaching learning sequence based on the Meaningful Learning theory. It was developed in the National Master's Professional Program in Chemistry – PROFQUI of the Federal University of Rio Grande do Sul, Brazil. Composed of five classes, organized in an experimental investigative manner using the Predict, Observe and Explain method (POE), it was applied with 28 students of the secondyear High School from a public school in southern Brazil. The results, mainly about the conceptual maps, analysed according to the case-by-case comparison method, show us the learning of Chemical Kinetics was facilitated, providing students not only the comprehension about mathematical aspects, but allowing the relationship of previous knowledge with scientific concepts, contributing not only to meaningful learning but also to understanding the connection between society and science.

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865 Study of the Mental Model of Volcano in Primary School Students, Through the Analysis of Drawings

Soraya Layton-Jaramillo[1], Araceli Garcia-Yeguas[1], Jane Scarrow[1], Eveling Espinoza[2], Carlos Rubi[3], Francisco Javier Carrillo-Rosua[1]

[1]University of Granada, Granada, Spain. [2]Instituto Nicaragüense de Estudios Territoriales, Managua, Nicaragua. [3]University of Nicaragua, Managua, Nicaragua

Abstract

Volcanic activity is a factor for landscape building, and causes a great impact on human beings and the natural environment. For this reason, the study of volcanoes is very important in hazard and risk assessment, as well as in mitigation planning. The aim of this paper is to study the image of a volcano that a group of Centroamerican primary school children have, in a place with high volcanic activity. This study carried on with a sample formed by 100 students with ages between 7 and 9 years old, plus 162 with ages between 10 and 15 years old, who drew a volcano. The drawings were analyzed according to the deductive categories: volcano shape, internal structure, human presence and disaster. The results indicate that the mental model of volcanoes of students is more influenced by what they see in the audiovisual media and other sources, than by their own experience with the volcanoes in the region where they live.

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750 Consistent and Inconsistent Mental Models of Ions in Solutions and Precipitation Reactions

Asmaa Atrash-Gnayem, Elon langbeheim

Ben- Gurion university, Beer Sheva, Israel

Abstract

In order to disentangle some the intricacy of explaining precipitation reactions, we analyzed 11th grade chemistry students' illustrations of ionic solutions and solid ionic precipitates. We focus on two typical pitfalls in students' reasoning: representing ionic substances as consisting of pairs of ions, and representing solid ionic material as "grains" of ions pairs or single ions. Through careful analysis of students' drawings and explanations, we suggest that about one third of them developed stable, incomplete mental models of ionic solutions, that hinder their understanding of precipitation reactions. About one quarter of the students developed less consistent mental models, that indicate partial connections between explanations of dissolving solid salts and the formation of precipitates.

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741 Differences in Students' Interpretation of Graphs Based on Eye Movements

Martina Kekule

Charles University, Prague, Czech Republic

Abstract

We used the eye-tracking method to observe students' strategies when they solved multiple-choice tasks focused on graph slope in kinematics. 32 high school students participated in the study. We provide comparison of attention allocation between different students' groups: those, who solved a test task correctly and those who solved the whole test the best; those, who solved a test task incorrectly and those who solved the whole test the worst. The best performing students spent less time looking at almost all options in contrast to correctly answering students. They do not differ in two quantitative tasks. The lowest performing students spent much more time on the typical options "graph as a sketch of a real situation" than on the other alternatives in contrast to the incorrectly answering students. Moreover, we applied the cluster analysis in order to divide students into groups according to their attention spent on each option. The groups of students so selected differed most in the time they spent reading the stem or the stem graph.

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518 The Literature Review on Teaching and Learning the Properties of Matter in Physics Education

Ayçin Ünal[1], Lorenzo Gianni Santi[1], Marisa Michelini[1], Mehmet Fatih Taşar[2]

[1]Università degli Studi di Udine, Udine, Italy. [2]Georgia State University, Atlanta, USA

Abstract

The purpose of this literature review is to identify, list, and analyze published research studies on teaching and learning the topic of "properties of matter" in relation to physics education. The search was conducted on Web of Science and Google Scholar databases. Twenty-one publications have been identified that complied with the search criteria. Our analysis of these articles yielded that published studies mostly employed qualitative research methods by focusing on K-12 students. The analysis further yielded specific categories in which these articles can be grouped. Finally, our analysis helped us to identify existing gaps in the literature and suggestions for further research on teaching and learning properties of matter.

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616 Meeting Between Spinoza and Gilles Deleuze: From Affection to Learning in Sciensces

Amanda Jardim, Carolina Rodrigues de Souza

Federal University of São Carlos, São Carlos, São Paulo, Brazil

Abstract

This paper aims to propose Spinoza's concept of affection and Gilles Deleuze's notion of "learning", based on the experience of encounter with signs, as an alternative to think about Science Education. The article questions Science Teaching based on Modern Science, traditionally focused on reason, and on a notion of objectivity, in the proposal of a Science

Education with all, and not for all.

434 Motivations, Emotions and Engagement to the Science Learning in Primary Students

Pedro Membiela[1], Katherine Acosta[2], Marlene Morales[2]

[1]University of Vigo, Ourense, Spain. [2]University of Tarapacá, Arica, Chile

Abstract

A research has been carried out with 250 students from primary schools on the relationship between motivations, emotions and engagement to science learning. In the results highlights the strong correlations that manifest the dimensions associated with motivation (science personal relevance, extrinsic motivation, self-efficacy, self-determination), with emotions (boredom, and enjoyment but not anxiety), and with the three dimensions of engagement. Also, highlight those motivational variables that have a combined effect as science personal relevance and enjoyment because increases vigor, dedication and absorption in science studies.

429 Influence of Contextual Variables in Primary Students Science Learning

Pedro Membiela[1], Katherine Acosta[2], Marlene Morales[2]

[1]University of Vigo, Ourense, Spain. [2]University of Tarapacá, Arica, Chile

Abstract

The research has been carried out with 250 primary school students. Contextual variables such as gender, age, course, and grade may be related to motivation, emotions, and engagement to science learning. There are no significant differences based on gender, and if based on age, except in self-efficacy and self-determination; also associated with the grade except for personal relevance, self-determination and enjoyment. Finally, significant differences related to the qualification are shown, except for anxiety.

410 The Change of Intrinsic Motivation Towards Science Learning Among Lower Secondary School Students Over Time

Moonika Teppo, Regina Soobard, Miia Rannikmäe

University of Tartu, Tartu, Estonia

Abstract

The decline in student motivation is an ongoing concern in science education, emerging especially during adolescent. This study examines the change in students' intrinsic motivation (in terms of interest/enjoyment, perceived competence, perceived choice, effort and value) towards science learning over a three-year period. Data were collected from 171 lower secondary school students who completed a self-reported questionnaire twice - initially in

grade 6 and three years later in grade 9. The results indicate a significant decrease in students' interest/enjoyment, perceived competence and value, although not in perceived choice nor effort towards science learning on comparing outcomes from grades 6 and 9. Based on the findings, it is suggested a more personalised approach to teaching is adopted promoting students' intrinsic motivation towards science learning in the lower secondary school. Results and implications for science learning at lower secondary level are discussed during the presentation.

49 Attitudes Toward Science at the End of Primary Education: Influencing Factors

Gloria Rodríguez-Loinaz

University of the Basque Country (UPV/ EHU), Lejona, Spain

Abstract

The aim of this study is to analyse the effects of different factors (gender, parents' profession, level of active learning and participation in science activities) on students' attitudes towards science (ATS) at the end of primary education. For this purpose, an ad hoc questionnaire, which included the Attitudes to Science at School Questionnaire, was designed and 181 pupils responded to it. The results showed that there was no effect of gender or level of active learning on students' ATS. However, students with parents with STEAM professions and students who had participated in hands-on science activities at school had a more positive ATS. In addition, the results showed a relationship between positive ATS and the desire to have STEAM careers. We conclude that increasing active learning does not necessarily have a positive effect on ATS, and that implementing context-based hands-on science activities can make a difference.

Parallel Session - 5.3 (Posters)

16:00 - 17:30 Tuesday, 29th August, 2023

Chair: Guia Bianchi

758 Bibliometric Analysis of Studies on 21st Century Skills in Science Education

İclal Alkan, Cihan Duman

İnönü University, MALATYA, Turkey

Abstract

In this research, it is aimed to reveal the trends and trends in the field by examining 359 studies on 21st century skills in the field of science education published between 1997-2022 in terms of bibliometrics. The study was structured on the basis of the descriptive research model. In this context, using the keyword group "21st Century Skills in Science Education", an online search

was made in the Web of Science database and bibliometric data of the studies were reached. Web of Science (WoS) categories of the publications that make up the data set, publication types, numerical distribution by years, keyword network, most cited articles, most cited years, active researchers, active journals, most cited authors, active countries and active institutions were included in the research. 586 records were obtained for 21st century skills in the field of science education. Studies were analyzed as data files using the VosViewer (1.6.18) software. According to the results obtained, it was observed that the majority of the studies were in the Education/Educational Research (f=329) category. In terms of publication type, it was determined that the most studies were in the article type (f=299), and the most studies were done in 2019. It was determined that the most frequently used keyword in the studies was "21st century skills" and the most studies were conducted in the USA.

1241 Technological Approaches in Mathematics and Science Education: Microlearning

Zümrüt Varol Selçuk[1], Gamze Mercan[2], Pınar Köseoğlu[2]

[1]Gazi University, Ankara, Turkey. [2]Hacettepe University, Ankara, Turkey

Abstract

With the help of digital technology, the time when educational activities were carried out according to predetermined patterns has given way to a learning process that is focused on the learner. According to the lifelong learning philosophy, education has been liberated from the constraints of time and space by the presentation of teaching materials in digital environments, and meeting learning needs has become a common practice for the general public by using open and distance learning systems. In addition to knowledge being so accessible, new methods have been developed to make learning in the cognitive environment simpler and faster. One of these methods is the idea of microlearning. Microlearning is regarded as a novel approach to meeting many learning demands, including individual learning, lifelong learning, and work-based learning. A learning strategy called microlearning focuses on giving students enormous amounts of (macro) material in manageable chunks over a little period of time. These little segments, also known as micro-content, help students retain the knowledge quickly without subjecting them to voluminous material. It is believed that breaking up the knowledge into manageable chunks helps learners better adapt to the information-processing process and acquire new material. With all of this in mind, it may appear that activities that allow students to actively engage in math and scientific studies, make connections to the real world, work in groups, support both their internal and external goals, and get lucid and insightful feedback are crucial. This study aims to investigate the design and implementation of microlearning, one of the technological approaches to math and science instruction, in informal, formal, and non-formal settings. It also explores the characteristics of micro content and how it relates to mobile learning using examples.

1232 E-Course Program Design for Teacher Training on Climate Change: ClimaTePD Project

Orhan Curaoglu[1], Yunus Ozyurt[1], Gultekin Cakmakci[2], Sonia Hetzner[3], Silvia Alcaraz-Dominguez[4], Katherina Kikis-Papadakis[5], Smaragda Lymperopoulou[5], Yorgis Androulakis[5], Emel Loeffelholz[3], Niclas Ophey[3], Bahadir Altintas[1], Maria Kalathaki[6]

[1]Bolu Abant Izzet Baysal University, Bolu, Turkey. [2]Hacettepe University, Ankara, Turkey. [3]FAU, Nürnberg, Germany. [4]University of Barcelona, Barcelona, Spain. [5]Forth, Heraklion, Greece. [6]Institite of Educational Policy, Crete, Greece

Abstract

This study aims to introduce the e-course design developed for pre-service and in-service teacher training on climate change. The e-course design was created as an output of the project "Practices for the Development of Teachers' Professional Competences on Climate Change (ClimaTePD)", project number 2020-1-EL01-KA226-SCH-094834, supported by the European Union ERASMUS+ program. The training program aims to demonstrate the possibilities of integrating climate education topics into different subjects and to enable teachers to develop teaching concepts on key topics related to climate change and climate protection. ClimaTePD is aimed at in-service secondary school and pre-service teachers developing digital competencies and teaching skills in climate change education. The training takes place online, regardless of time and place. There is no specific time when the work must be done. Most of the activities are asynchronous. In some cases, synchronous activities are also carried out in order to encourage collaboration and interaction. The content of the training is structured in 3 main parts with a total of 6 units. Those who complete the training are entitled to receive a certificate.

1076 Elaboration of the Audiovisual Material to Facilitate the Teaching and Learning of Stoichiometry in Public and Private Schools in Brazil

Maximiliano Segala, Sabrina dos Santos, Daniele Raupp

Federal Universita of Rio Grande do Sul, Porto Alegre, RS, Brazil

Abstract

The content of Stoichiometry is generally seen by students as among the hardest subjects to understand. This could be observed through our experience as high school teachers, in public and private schools, in Brazil. We realized that new didactic resources are necessary to minimize such difficulties, helping in both teaching and learning processes. Classroom materials produced by the teachers themselves should be more efficient as they portray their own school reality, making teaching, in a way, personalized. In addition, such classroom materials should be made available online in order to serve the largest possible number of students. This work involves the creation of an educational product, presented as an audiovisual resource since that brings very efficient elements in the teaching and learning process, such as movement, colours and sounds. It was developed in the National Master's Program Professional in Chemistry

PROFQUI of the Federal University of Rio Grande do Sul. We created a YouTube channel, which features the solution of stoichiometry exercises of increasing level of difficulty. The videos were recorded using a smartphone and edited in a free software, in a process that can be reproduced by any teacher who has access to the internet. In this way, our work mainly aims to develop such materials to serve as an inspiration for teachers to create their own classroom materials, based on the school reality in which they are engaged. Questionnaires were applied before and after using the material. The data collected was analysed from the perspective of Bardin´content analysis. It showed great results in terms of improving Stoichiometry learning, results verified through a questionnaire about the students' perception of the stoichiometry content, a pre and a post-test, as well as, another about the students' impression of the material produced.

1023 Characterising the Educational Potentials of Citizen Science Mobile Applications Related to Biodiversity

Giuliana Morbidoni-Davicino[1], María Carla Lábaque[2,3], Leticia Garcia-Romano[1,3]

[1]Science and Technology Teaching Department, National University of Córdoba, Córdoba, Argentina. [2]National University of Córdoba, Córdoba, Argentina. [3]National Scientific and Technical Research Council (CONICET), Córdoba, Argentina

Abstract

Twenty free-download citizen science mobile applications (apps) aimed at teaching and learning about biodiversity conservation are characterised. The analysis includes characteristics related to multimedia, content, citizen engagement and collaborative learning. The results show that there is a diversity of areas of knowledge on biodiversity where citizen science can be developed, and that multimedia resources favour the successful identification of organisms. In addition, several apps allow citizens not only to collect data but also to participate in scientific projects, thus favouring collaborative learning and recognition of their immediate environment. It is recommended that teachers select apps such as Naturalista, Natusfera, PlantNet, Appear, Geovin and Global Observer, since they have the greatest potential for taxonomic identification and offer the possibility of linking more closely with scientific projects related to biodiversity conservation.

598 The Explanations of Physics Teachers in Classes With Remote Laboratories

Ignacio Idoyaga[1], Nahuel Moya[1], Gabriela Varela Belloso[2], María-Gabriela Lorenzo[1,3]

[1]Universidad De Buenos Aires, Buenos Aires, Argentina. [2]Consejo Federal De Educación, Montevideo, Uruguay. [3]Consejo Nacional De Investigaciones Científicas Y Técnicas (Conicet), Buenos Aires, Argentina

Abstract

This paper presents a qualitative descriptive study on the explanations of three university Physics' teachers in kinematics classes with remote labs. These technological tools, made up of software and hardware, allow teachers and students to carry out experimental activities at a

distance because users have access to real lab equipment and can control it by a virtual interface. The principal objective of the research is to describe and characterize some aspects of teachers' explanations when they use remote labs to teach Uniformly Accelerated Rectilinear Motion. This study was performed in a Physics freshman course of Universidad de Buenos Aires in 2022. Methodology included non-participant observation, audio recordings and transcriptions of classes where a remote lab was used. The transcriptions of classes were analysed using Content Analysis and pre-constructed dimensions and categories. The results showed that teachers used guided strategies, recognized the ease of use of remote laboratories and their versatility to teach concepts and procedures, and understood them as a replacement for the hands-on labs. In addition, limitations for the time of use allowed and strategies of exploratory cut, were also found. The central role of teachers in the process of including technology in class and the possible limitations that the results found would imply are highlighted in the conclusion. It reveals the persistence of traditional laboratory practices, even if teachers use new technologies. In this sense, guiding strategies could limit remote labs possibilities, avoiding students to repeat experimental practices many times and regulate their own learning. Moreover, considering remote labs as substitutes of hands-on labs could prevent the inclusion of these kinds of devices in innovative educational projects. In addition, the importance of continuing with research on remote laboratories in higher education is raised.

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580 Pre-Service Science Teachers' Experiences of Simulation Development Using Coding

Emine Eren, İlbilge Dökme

Gazi University, Gazi Faculty of Education, Science Education Department, Ankara, Turkey

Abstract

Block-based coding programs are mostly used for robotics applications in science/STEM classes. However, this study focuses on the use of block-based coding programs for developing simulations about science/STEM subjects. In this study, views of 2nd-year pre-service science teachers, who learned a block-based coding program for the first time and developed simulations for science/STEM subjects in this program, were analyzed. The findings were obtained through content analysis of semi-structured interview records. Initial findings revealed that although pre-service teachers faced some difficulties, they considered developing simulations using block-based coding programs easy, practical, and useful. The pre-service science teachers' views indicate that they use simulation development for teaching many different subjects. Furthermore, some views emerged that pre-service teachers consider themselves more qualified as STEM teacher candidates since they can develop science simulations using such coding programs. The findings are still being analyzed.

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575 Responding to COVID-19: Transforming a Doctoral Summer School to an Online Experience

Sarah Frodsham[1], Deb McGregor[2], Allison Cullinane[3], Liam Guilfoyle[1], Judith Hillier[1]

[1]Oxford University, Oxford, United Kingdom. [2]Oxford Brookes University, Oxford, United Kingdom. [3]Edinburgh University, Edinburgh, United Kingdom

Abstract

In March 2020, the COVID-19 pandemic reduced international travel and non-essential face-to-face interaction. This could have proved problematic for one of the leading international science education research organisations. They had for over 28 years regularly provided a week-long summer school experience for doctoral students. To continue the summer school support for European doctoral students (studying for a PhD) an online transformation that facilitated and maintained the previously well established productive learning interactions between mentors and doctoral students was required. This required a virtual week-long doctoral summer school experience to be generated within three months to ensure the original deadline in the summer 2020 was achieved. To investigate the effectiveness of the inaugural online summer school all PhD students, from across five continents, were invited to reflectively comment on their educative experience. This paper presents the findings from analysis of the views shared by the students who attended. The overall impact of the digital transformation was examined by adopting a multi-method approach. The students' views were collected through an online questionnaire and semi-structured interviews to elicit how the range of varied online interactions maintained learning opportunities and also facilitated their introduction to the well-established research community. The study indicates how the digital activities helped to preserve the high-quality learning exchanges whilst also augmenting a feeling of 'becoming' and 'belonging' to a well established research community by facilitating activities involving both experienced and novice scholars. Findings will also discuss how successful academic outcomes can be achieved remotely whilst minimizing international travel and significantly reducing financial outlay. This was achieved through creatively structuring and framing a week-long virtual experience through combining synchronous and asynchronous learning opportunities for different groupings of students within the international summer school community.

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486 Stranger Fields, a Serious Game to Learn Kinematics: A Preliminary Study With Undergraduate Students

Emmanuel Rollinde[1,2], Bertrand Laforge[3], Thomas Planques[4]

[1]CY Cergy Paris Université, Cergy, France. [2]LDAR, Paris, France. [3]LPNHE, Université Paris VI-Pierre et Marie Curie, Paris, France. [4]Ikigai, paris, France

Abstract

Stranger Fields (SF) is a "serious game" in an astronomy context that was set up to support a mechanics course in the first year of university on the notions of forces and interactions. Students are playing the role of a mad scientist who shoots missiles to destroy Earth. The

missiles may be send with different initial speed and direction. The presence of black (white) holes with positive (negative) mass may attract or deflect the trajectory of the missile. To reach Earth, the player needs to foresee the trajectory of the missile. It acquires then an intuition of gravitational trajectories. Through a conceptual test (FCI) and direct observations of students' activities, we analyze if and how SF facilitates the understanding and the usage of Newtonian mechanics. The first year implementation with a focus group (30 selected students and 11 declared players) gave us confidence in the ease of use of the game and on its potential impact on learning. The second year, an a-didactical situation – the Newton's cannonball, was given to 8 groups of 4 students during a problem-solving session. Through the observations of both the teacher and students, we analyze how and when SF was used during the resolution of the problem. We conclude that SF provides a valuable help in the visualization of the solution and to the process of "modelisation" led by students.

1029 Re-Blossoming as a Theoretical Framework for Researching the Perspectives of Students Regarding Islam and Science in Schools

Usama Javed Mirza

University of Cambridge, Cambridge, United Kingdom

Abstract

After the advent of direct exploitation-colonialism of traditional Muslim lands from North Africa to the Pacific, traditional Islamic indigenous academic discourse and its associated teaching and research institutions were systematically transformed. This epistemicide (Santos, 2014), often a consequence of the direct hegemony of European colonial rule, diminished and dismantled the Islamic science tradition, and replaced it with a monoculture of 'modern' science (Santos, 2007). Muslim reformers since this era of colonial rule have responded to this modern science, with its secular epistemology and ontology, through a spectrum of approaches ranging from rejection to embracement to reconstruction of both scientific and religious thought. These ideological orientations regarding the relationship between modern science and Islamic science tradition remain in flux behind the scenes in science education in schools in the Muslim world. How Muslim youth engage and take action on socio-scientific issues like climate change and population control is strongly influenced by the legitimacy they give to secular and religious sources of knowledge, and those corresponding community leaders. This paper presents a theoretical framework called re-blossoming for analysing the perspectives of Muslim students on the relationship between Islam and science. To re-blossom the Islamic science tradition is to reinvigorate its intellectual rigour and prestige as a living tradition in contemporary times that takes the positive elements (methods, epistemological framework, ethics, professional collaborative norms and institutions) of the tradition in the past, and the Western modern science tradition. Re-blossoming is positioned in contrast with, though borrowing from,'revival' discourse among Muslim reformists, as well decolonial discourse. Finally, the power of using a re-blossoming framework for understanding empirical data on science and Islam discourse in Muslim schools with the social justice aim of countering coloniality/modernity (Mignolo & Walsh, 2018) is presented.

Parallel Session - 5.4 (Posters)

16:00 - 17:30 Tuesday, 29th August, 2023

Chair: Olivia Levrini

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262 Exploring Turkish Preservice Teachers' Views about Nature of Science During an Undergraduate Course

Osman Aksit

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Abstract

While past science curriculum reforms emphasized the importance of facilitating students' informed conceptions of nature of science (NOS) as part of their regular science learning in schools, previous studies consistently showed that students lacked a proper understanding of NOS and hold various misconceptions in this area (e.g., theories become laws after substantial evidence). Researchers and policymakers pointed out the crucial role teachers play in the success of these reform efforts on NOS in K-12 science education. While many studies investigated preservice and in-service teachers' knowledge and beliefs about NOS, most of these studies were conducted in Western and/or developed countries. More research is needed regarding teachers' NOS conceptions in developing countries such as Turkey in order to formulate specific policy suggestions for these countries. The present study aimed to investigate Turkish preservice teachers' prior knowledge of NOS and the impact of attending an undergraduate-level course, which explicitly introduced different NOS concepts, on preservice teachers' understanding of NOS. The study was conducted at a public Turkish university and the sample consisted of twenty-nine teacher candidates. According to the results, the preservice teachers who participated in this study did not demonstrate an adequate understanding of various NOS concepts at the beginning of the course. While there were some significant improvements in participants' understanding of a subset of the NOS concepts addressed during the course, their overall performance was still below expectations. The findings of this study have implications for helping teacher candidates acquire informed conceptions of NOS during their teacher preparation programs.

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415 Teaching Nature of Science: A Science Teacher's Autoethnographical Reflections

Büşra Aksöz, Ebru Kaya, Ayşegül Çilekrenkli

Boğaziçi University, İstanbul, Turkey

Abstract

This auto-ethnographic study is a part of a funded project. Through the project, NOS embedded science course was taught to fifth-grade students for a semester at a public school

in Turkey. The science teacher who implemented NOS teaching in her science lessons was one of the researchers in the project. The current study aims to investigate the teacher's reflections on the inclusion of NOS in the Turkish science education program and science textbook, her process for what did go well for teaching NOS, the students' progresses in learning NOS, and her developmental progress through the intervention. The Reconceptualised Family Resemblance Approach to the Nature of Science (RFN) was chosen as the framework for teaching NOS to fifth graders, and lesson plans for three modules were developed. For thirteen weeks, the teacher gave the experiment group regular education while the control group received RFN-based training. The teacher kept weekly journals throughout the intervention, answering 15 questions which 6 of them was answered before the implementation and 9 of them after the implementation. In the current study, the findings of her reflections through the journals will be presented. Thematic and content analysis were used to analyse these journals. The teacher thinks that both the curriculum and science textbook has so limited explicit connections to NOS. Students in the experiment group started to make explicit connections to NOS, answer NOS-based questions referring to visuals they used in the lessons and think of science in a holistic way. The instructor believed that this project gave her the opportunity to teach NOS in a more systematic and holistic manner. Also, she reflected on her suggestions for teaching each RFN category to the teachers to provide them with practical advice for implementing RFN in the science classroom.

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487 21st Century Science Teachers' Nature of Science Content Knowledge

Dominik Tschirky[1], Kerstin Kremer[2], Nicolas Robin[1]

[1]St.Gallen University of Teacher Education, St.Gallen, Switzerland. [2]Justus Liebig University Giessen, Giessen, Germany

Abstract

An adequate understanding of science knowledge and knowing is more present than ever in a knowledge society. In science education, this is discussed under the topic Nature of Science (NOS). Newly formulated educational standards and curricula have given NOS ongoing meaning for prospective and current teachers. The teaching and learning of an adequate understanding of science comes into focus. Thus, there is a demand for profound knowledge for science teachers, who initiate and support learning opportunities in the corresponding competencies. Despite decades of heated discussions from various disciplines about the meaning, content and scope of NOS, further sharpening of the construct is needed. The recent debate is partly due to the changing relationship between science and society. Contemporary methods and technologies, media or communication are asking science education constant re-conceptualizations of NOS for teacher professional knowledge. The demand for professional, scientific-technological training of young scientists in a rapidly changing society requires a constant reflection on the Nature of Science for teacher education. Therefore, it is time to collect and evaluate the different perspectives and contributions that NOS research has produced. The goal of the sub-study of a dissertation presented in the poster is the consolidation and further development of existing theoretical approaches into a NOS Content Knowledge model for

teacher professional training. The expected results should contribute to a theoretical sharpening of the construct of NOS Content Knowledge for science professional development in the 21st century. Likewise, based on the model, a valid, quantitative instrument aspired, which considers the holistic, contextualized character of NOS Content Knowledge in the survey. Thus, both the theoretical considerations over time in the research community and the lack of empirical instruments in the discourse are taken into account.

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643 Evolution of the Conceptions of the Nature of Science in Alternative Teacher Certification Programs Students

Ruby Olivares-Donoso[1], Verónica Acevedo[2], Renata González[2]

[1]Pontificia Universidad Católica de Chile, Facultad de Educación, Departamento de Didáctica, Santiago, Chile. [2]Pontificia Universidad Católica de Chile, Santiago, Chile

Abstract

One of the primary purposes of science education today is the formation of scientifically literate citizens. A critical factor in achieving scientific literacy is that students accurately understand the nature of science (NOS). Knowing how prospective teachers conceive this topic is essential because it shapes how their students learn science. This research aims to analyse the NOS conceptions held by students of Alternative Teacher Certification Programs (ATCPs) with majors in scientific disciplines (biology, physics, and chemistry) and how their conceptions change over time. Semi-structured interviews were carried out with 36 first-semester students from six ATCPs at three moments: at the beginning (1st moment) and the end (2nd moment) of the ATCP and during the first year of the professional practice (3rd moment). The analysis of five case representatives to illustrate the evolution of the NOS conceptions over time is presented here. Although all the participants follow different trajectories, at the end of the training process and the beginning of the professional practice, they all have advanced conceptions of NOS. These findings could contribute to the decision-making of ATCPs regarding designing and implementing science teaching methods courses that improve the understanding of the NOS and promote its use in professional practice.

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850 Public Trust on Science and Science Education: A Missing Link?

Cláudia Faria[1], Isabel Chagas[1], Cecília Galvão[1], Paula Serra[2], Hélia Oliveira[1], Miia Rannikmäe[3]

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Abstract

The main objective of this study was to analyse the potentialities of a High-Fliers didactic module to promote the understanding of the nature of the scientific knowledge and research processes as opposed to pseudoscience by secondary students. The research followed a mixed

approach, with a pre- and post-questionnaire on the importance of a set of important skills (communication, research, thinking, social, and self-management) at a professional and at a personal level, and the content analysis of two different products, a students' written explanation about what is science (initial task) and a three-minute video creation on a controversial STEM topic (final task). The results showed that the module was important not only on helping students to better understand the importance of the research skills, but also on developing their understanding of the distinctive characteristics of the scientific knowledge and research processes used in science as opposed to pseudoscience. This study emphasizes the importance of including nature of science issues as an explicit and regular component of science education, to foster a better understanding and trust in science, scientific knowledge and research, an urgent and very current need.

1025 The Use of the Metacategory Approach in the Teaching of the Nature of Science in Chemistry Students

María Órdenes, Diego Maltrana

Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile

Abstract

The nature of science (NOS) in scientific training curricular documents is relevant, its teaching contributes to forming scientifically literate students, who can generate significant learning. The research aims to analyze the teaching and learning process of aspects of the nature of science, through the use of an innovative theoretical approach that promotes the comparison between scientific and non-scientific human activities. This research considers a qualitative study, with a descriptive approach, whose main method is a collective case study. The development of four phases consist of design, implementation and evaluation of class activities using historical episodes, the metacategory approach (MCA), and characterization of students' experiences in class activities. The participants will be students in the last year of Pedagogy in Secondary Education with a major in Biology and Chemistry who are studying a one-semester elective course. The theoretical relevance considers providing theoretical references that allow the study of various approaches to NoS. The methodological relevance consists of the creation of didactic strategies through the design, implementation and evaluation of class activities that contribute to understanding how the generation of scientific knowledge occurs and humanizing the theoretical contents through its historical development. Finally, the practical relevance consists of innovating in the educational processes of epistemic and non-epistemic aspects of NoS, promoting opportunities for future teachers to identify with science, perceive it as significant and relevant which also allows modifying preconceived ideas about who can do science.

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150 Adressing Challenges in Measuring Interest

Rauno Neito[1], Kaido Reivelt[1], Jari Lavonen[2], Elisa Vilhunen[2]

[1]Institute of Physics, Faculty of Science and Technology, University of Tartu, Tartu, Estonia. [2]Faculty of Educational Sciences, University of Helsinki, Helsinki, Finland

Abstract

This pilot study aimed to address issues related to measuring situational interest. Estonian 8th and 9th-grade students (n=180) participated in workshops that aimed to support students in making sense of oscillations. A range of instructional activities was implemented to trigger situational interest. The data was collected using the experience sampling method, and interest was measured on a 5-point Likert scale multiple times during the workshops. In addition, students' personal interest in physics was measured at the beginning of the workshops. The results revealed that response rates to interest questions were significantly lower than initial background and topic-related questions. The data collection procedure was designed to interrupt the students and the lesson flow as little as possible, which inadvertently had a negative impact on their response rates, i.e., students were too engaged to notice the interest questions. No correlation between response rate and students' gender, grade, workshop groups (except for one group) or personal interest was detected. The study also did not confirm a significant correlation between instructional activities and interest; levels of interest for all workshop activities were high. Similar studies measuring the same construct have shown a significant correlation, but the difference in levels of interest have been marginal. These findings suggest that extra care must be taken when measuring lower secondary students to avoid attrition and excess cognitive load by limiting the number of questions. Second, a different kind of approach in terms of measurement scales might be necessary when dealing with this age group. We suggest a more concrete option, such as a binary scale or a scale with faces instead of numbers.

1166 Adaptation of the Abbreviated Science Anxiety Scale to Turkish

Nail ilhan, Öznur İkikat

Inonu University, Malatya, Turkey

Abstract

The purpose of this study is to adapt "Abbreviated Science Anxiety Scale"(ASAS) developed by Megreya et al. (2021) to Turkish and to investigate the validity and reliability of the adapted Turkish scale. The study group consists of 410 students from grade 5, 6, 7 and 8 of middle school in Malatya province of Türkiye. Data obtained from ASAS were analysed as descriptive statistics. The ASAS with 9 items was in a 5-point Likert type. In addition to the descriptive statistics, a confirmatory and exploratory factor analysis was performed to reveal the item analysis and factor structure. The adaptation stage decision shows the two-factor structure of ASAS. These factors are learning science anxiety and science evaluation anxiety. As a result of the analysis, the Cronbach alpha reliability coefficient for ASAS was calculated as 0.703. The

results show that ASAS is a short, valid and reliable tool. Low scores on the scale indicate low anxiety and high scores indicate high anxiety. It can be used to guide and enhance scientific education.

1176 Cognitive Structures of Science Teachers on Skill-Based Questions

Sultan Şan, Nail İlhan, Basri Yurttaş

Inonu University, Malatya, Turkey

Abstract

The aim of this study is to reveal the cognitive structures and perceptions of science teachers towards skill-based questions. For this purpose, descriptive survey model was used. Data were collected from 67 teachers working in the Eastern Anatolia Region of Turkey, the participants of the study, face-to-face and through google form. Snowball sampling was used in order to determine the teachers who actively use skill-based questions at 5th, 6th, 7th and 8th grade levels. The word association test (WAT) was used to collect data to reveal the cognitive structure. In WAT, three phrases were given. These are skill-based questions, the skills measured by the skill-based questions and the skill-based questions indicators. Teachers were asked to write the first five words that came to mind, and then write a sentence. In the analysis of the data, the most repetitive words/phrases were determined by using descriptive analysis. It is seen that science teachers' reading comprehension and interpretation skills are among the first ones that come to mind, for measured skills and the indicators related to skill-based questions. When teachers were asked to the sentences for a skill-based question, they stated that they enabled students to make inferences, and provided multi-dimensional thinking. According to teachers, skills measured by skill-based questions; thinking skills, high order thinking, life skills, problem solving skills, scientific process skills, 21st century and etc. As the indicators of skill-based question, it emerged as difficult, long, containing tables/graphics/images/figures, complex and context-based questions.

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519 Home Minerals Search: An Activity to Understand the Relationship Between Geology and Society

María del Mar López-Fernández, María José Cano-Iglesias, José Manuel Hierrezuelo-Osorio, Antonio Joaquín Franco-Mariscal

University of Málaga, Málaga, Spain

Abstract

Despite the relevance of the study of minerals because of their link to everyday life, the curricula's interest in extending it and the students' interest in learning about them is increasingly reduced. Therefore, the teaching-in-context approach becomes an opportunity to promote this topic in the secondary school classroom as it allows students to reflect on the properties and uses of minerals in everyday life. This work presents a synthesis activity in a teaching-learning sequence on minerals for 12-13 years-old Spanish secondary school

students. The activity consists of searching for minerals applications in their own home and creating, together with the whole class, a mural of a house showing the location and use of different minerals. The activity allows students to acquire knowledge about minerals while valuing the importance of these socio-scientific issues for their lives, thus linking geology with society. The students were satisfied with the activity's usefulness, interest and attractiveness and perceived progress in their learning about minerals.

Parallel Session - 5.5 (Posters)

16:00 - 17:30 Tuesday, 29th August, 2023

Chair: Özgül Yılmaz Tüzün

1207 Collaborative Interdisciplinary Practices in a Teacher Professional Learning Community: A Case Study

Lorena Rojas[1], Carlos Vanegas[2], Nicole Abricot[3], Gloria Romero[3], Gonzalo Guerrero[4], Johanna Orellana[5]

[1]Facultad de Educación, Pontificia Universidad Católica de Chile, Santiago, Chile. [2]Facultad de Ciencias, Universidad de Santiago de Chile, Santiago, Chile. [3]Facultad de Humanidades, Universidad de Santiago de Chile, Santiago, Chile. [4]Institute of Education, University College London, Santiago, Chile. [5]Colegio Centenario, Santiago, Chile

Abstract

In Science Education, today's global problems need to be addressed, more than ever, from a holistic perspective. Several international educational standards have proposed the need for cross-curricular learning for the development of socio-scientific knowledge. However, the disciplinary specialization of teacher training has not been able to balance the specific-didactic knowledge with the intersection between disciplines to teach collaboratively. To address this issue, a teacher professional learning community decided to develop a collaborative method to promote interdisciplinary learning in their students from the perspective of didactic sequences based on socio-scientific problems. This study introduces the aplication of this method from the teacher's collaborative practices experience, and the institutional management process, to the implementation of the classroom teaching practices. The aim of the study is to explore the interdisciplinary collaborative practices of a teacher professional learning community formed by elementary and middle school teachers. The data corpus considers co-operative design artifacts, in which six in-service teachers from middle and secondary level in collaboration with five researchers from a public University in Chile collaborated together throughout the whole project. Findings reveal two types of interdisciplinary collaborative practice: temporary practices and transversal practices. Some of these practices coexist or are intertwined in a longitudinal collaborative work process that

allows the creation of new professional and situated knowledge.

1204 Science Educators Doing Science: Enhancing Practice through Authentic Participation

Brant Miller

University of Idaho, Moscow, Idaho, USA

Abstract

Over the past five years, a team of faculty and students have conducted field work on endemic land snails in the Galapagos to understand complex questions around evolution. Beginning in June of 2018, a team of faculty from Biology and Science Education along with undergraduate and graduate students have traveled to the Galapagos to do research on land snails, specifically from the genus Naesiotus. I took the opportunity to immerse myself in the land snail research and explore how the nature of science (Lederman & Lederman, 2014) plays out in real time for scientists, and in so doing, come to a better understanding of the nature of science as a science educator. The research questions driving this work are: 1) How is science negotiated in the field? 2) How is the nature of science made explicit in a field research setting? 3) How does the experience of doing science impact a science educator whose job it is to prepare future science teachers? Data for this research was in the form of interviews, focus groups, reflexive journal entries and observational field notes while in the Galapagos. Data was analyzed using a constant comparative method (Glaser, 1965) keeping in mind the aspects of the nature of science (Schwartz, Lederman, & Crawford, 2004). Findings strongly relate to the nature of science aspects of sociocultural embeddedness and the tentativeness of science. In this presentation attendees will hear about the adventure of doing field work, how the nature of science unfolds in the field for participants, and how I, as the science educator on the trip, made sense of the experience and how it impacted my science methods course. Additionally, I make the call for why authentic participation in scientific research is key for science educators to enhance practice.

1188 Education of Complex Problems in Initial Training for Risk Management by Pre-Service Science and Mathematics Teachers

Pina Sollero, Maurício Pietrocola

University of Sao Paulo, Sao Paulo, SP, Brazil

Abstract

Most of the problems modern society faces nowadays are of the complex kind, which are multifactorial and do not have a single right and definitive answer. The COVID-19 pandemic highlighted our difficulty in dealing with dilemmas of that sort. To meet this demand we run a risk course in initial training so that preservice Science and Mathematics teachers are able to prepare their students to deal with complex problems. The undergraduates were introduced to literature on Risk Society and its implications for citizenship and, then, asked to create a

teaching-learning sequence (TLS) to educate their students how to make decisions based on judgments. This course was applied in four versions between 2020 and 2022 using the Design-based research methodology (DBR), a pertinent tool to understand how didactic materials are conceived and appropriated by preservice teachers. Preliminary results shows that the course about risk increased preservice teachers' risk perception on global threats and helped them make better decisions, which was evidenced by their critical review of the texts presented in the course syllabus and their final TLS. It is important to point out, however, that their ability to approach the dimension of certainties (data, analysis, concepts) was clear while they struggled with the unknown domain (weighing pros and cons) ratifying the importance of broadening the incorporation of risk topics in the curriculum.

490 Looking for Textbook Tasks With Interdisciplinary Character and Their STEM-Related Classification

Lukáš Rokos[1], Libuše Samková[2], Vladimíra Petrášková[2], Hana Boublíková[2], Eliška Kreklová[2]

[1]University of South Bohemia in České Budějovice, Faculty of Education, Department of Biology, České Budějovice, Czech Republic. [2]University of South Bohemia in České Budějovice, Faculty of Education, Department of Mathematics, České Budějovice, Czech Republic

Abstract

In this contribution, we present an analysis of several Czech textbook series for lower-secondary schools. This analysis was conducted from the perspective of potential of the tasks for STEM-oriented education. In our analysis, we include textbooks related to mathematics, science, and technology. In this proposal, we present a system of categories elaborated for all involved school subjects and illustrative examples from mathematics textbooks. We report ongoing research; complete results including illustrative examples and quantitative diagrams for all types of textbooks will be available at the conference.

459 How Is Systems Thinking Addressed in Science Education?

Ülkü Seher Budak, Gaye Defne Ceyhan

Bogazici University, Istanbul, Turkey

Abstract

The systems thinking approach requires understanding and interpreting complex systems (Senge, 1990). Student's ability to understand and contextualize complex dynamic systems should be developed to see the big picture (Evagorou et al., 2009). This research aims to investigate how the systems thinking approach in science education is positioned in peer-reviewed empirical research articles and to present the trends used in the current literature. In this study, a systematic review of open-access and empirical peer-reviewed articles indexed in the Web of Science database until the end of 2022 was performed to analyze the studies on systems thinking in science education. The results revealed that the research on systems thinking in science education has increased in recent years, mainly conducted from the United

States and Germany. Most studies focused on middle and high school students, and ecosystems are the most commonly addressed domain-specific topic. More than half of the reviewed articles mostly used complexity, relationships, components, interactions, interrelationships, and dynamics as characteristics of systems thinking. There is also uncertainty in the use of the characteristics, skills, and abilities of systems thinking, and these three terms are mainly used interchangeably. The reviewed findings presented the topics in which systems thinking was used, the studied participant groups, and how systems thinking characteristics, skills, and abilities were positioned. This research can provide evidence-based indications of areas that need further investigation in future research.

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269 Application of STEAM Model and Design Thinking: A Collaborative and Interdisciplinary Apporach to Solving Industry Challenges

Yin Fah Lee[1,2], Tzu-Hua Wang[1], Ming Tay Foo[3], Kee-Fui Lam[4]

[1]NTHU, Hsinchu, Hsinchu, Taiwan. [2]LOF Consultants Pte Ltd, Singapore,. [3]Goshen Consilium Pte Ltd, Singapore. [4]Edu-Aequitas Pte Ltd, Singapore

Abstract

The need for interdisciplinary knowledge and skills has never been greater in an increasingly complex world. The ability to think critically and solve complex problems spanning traditional disciplinary boundaries is essential for success (Brassler & Dettmers, 2017; Lam et al., 2019; Magno, 2010). Interdisciplinary thinking allows us to see the world more holistically and to identify connections that might otherwise be missed, through understanding the complexities of the systems we live in and developing creative solutions to the challenges we face (Forrester, 1994). The purpose of this study was to expand the mindset and elevate the approach to problem solving through a corporate setting. The researchers have structured the project using STEAM-Design Thinking (STEAM-DT) Model to address the feasibility of this study. The objectives of this study were to (1) improve the efficiency of the organisation, (2) integrate data analytic capabilities, and (3) improve data and financial security (IDEO, 2023; Wruck, 1990; Yakman, 2008). Initial focus group discussion (FGD) was conducted on the company's management (Köppen & Meinel, 2015). The researchers interviewed direct users and discovered the detailed activities that affected operation efficiencies, and defined the problems, stakeholders, and user stories. Following, periodic tests were conducted to gather user feedback and improvement over development cycles (SPRINT) via a prototype modelled using wireframes and mock-up layouts. Throughout the study, the researchers actively mapped the STEAM competencies such as critical thinking and problem solving to the Design Thinking Process, enabling the participants to revisit and address the challenges from an interdisciplinary lens. Finally, the study was completed by implementation of the Collaborative Platform providing Integrated Enterprise Solution on Procurement. In conclusion, the initial study of incorporating STEAM-Design Thinking Model into organisational development setting showed efficacy and through this, it paves the way for more in-depth studies to be conducted.

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622 Undergraduate Students' Decision-Making Towards Consensus Building and Web Searches on the Socio-Scientific Issue of the Swine Fever Vaccine

Etsuji Yamaguchi, Miki Sakamoto

Kobe University, Kobe, Hyogo, Japan

Abstract

This study explored non-science undergraduate students' socio-scientific issue (SSI) -focused web searches and post-search decision-making. It focused on socio-scientific decision-making towards consensus building, which emphasized generating solutions to resolve issues and gaining insight into how to facilitate socio-scientific decision-making in the digital world. The participants were 40 non-science undergraduate students. Students completed an essay task individually to assess their decision-making competencies. Students responded to the interview questions, especially on the websites they cited. The data source for this study is the socio-scientific decision-making task and the post-task interviews to reflect the process of web searches. By conducting web searches, non-science undergraduate students were able to perform a certain level of decision-making. However, there are concerns about whether their web searches were appropriately conducted and whether unbiased information was obtained and used for their decision-making. Interventions to improve the quality of web searches, such as collecting information from multiple perspectives and encouraging awareness of trade-offs, are needed to promote decision-making.

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495 Enhancing Engineering Students' Knowledge and Scientific Practices by Engagement on Developing STEM Projects

José Gutiérrez-Berraondo[1,2], Mario Arrue[1], Iker Gallardo[1]

[1]Escuela Universitaria de Ingeniería Dual, Elgoibar, Gipuzkoa, Spain. [2]Donostia Physics Education Research Group. Applied Physics Department, University of the Basque Country (UPV/EHU), Donostia, Gipuzkoa, Spain

Abstract

This study addresses the implementation of a project in the first year of an engineering degree by designing a teaching-learning sequence to scaffold students in solving the project. The work presented here integrates the STEM disciplines, in this case physics, mathematics, computer science and engineering, in the development of the project. Its results show the extent to which science content learning and science skills practices have been achieved by students through the project solution process. The analysis focuses on key issues related to: a) physics (work and energy), mathematics (derivatives and graphs) and programming concepts; b) the use of scientific and technical skills. It is found that there is a good of students' progression in the understanding of concepts, but in the evaluation of students' use of scientific skills the results obtained are not so good to the expect.

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446 Junior High School Teachers' Familiarity and Agreement with Astrology

Chiao-Yun Su, Huei Lee, Chia-Ling Chiang

National Dong Hwa University, Hualien, Taiwan

Abstract

Astrology, a kind of belief based on the movement of stars, has been around for 3,000 years and has recently gained popularity in Taiwan. If people only treat astrology as a topic of conversation after meals, it may not have a major impact. However, gradual internalization of believing in astrology can influence self-image, reinforce stereotypes, affect social relationships, and lead to discrimination. Since teachers are important others to teenagers, this study aimed to understand the level of familiarity and agreement among junior high school teachers with astrology. A questionnaire titled "Teachers' Familiarity and Agreement with Astrology" was distributed to 113 junior high school teachers. The questionnaire has 47 items and is divided into two parts: familiarity and agreement. Each part is further divided into four faces: "basic assumptions of astrology", "influence on personality", "influence on fate", and "zodiac sign compatibility". The results indicate that teachers are familiar with astrology, but they do not hold strong opinions about it, being neither strongly in agreement nor strongly in disagreement. There is no significant difference in familiarity or agreement based on gender, but there is a difference based on academic background, as non-STEM major teachers tend to have higher agreement about astrology. Interestingly, STEM major teachers do not necessarily disagree with it, which challenges the expectation of scientific rationality and is worth further exploration.

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499 Chemistry Education in the Context of Climate Change: Enhancing Critical Thinking to Address Global Challenges

Shelley Rap, Hanan Gbarin, Ron Blonder

Weizmann Institute of Science, Rehovot, Israel

Abstract

The advancements in media technology have presented new challenges for individuals seeking to engage in and better understand science. The abundance of information on the internet requires a deeper evaluation of information, making it crucial to provide students with the necessary skills to evaluate and analyze the wide range of information available to them. One of these skills is critical thinking, which involves evaluating beliefs and determining actions. To foster critical thinking, teachers should cultivate a passion for discussing and questioning ideas among their students. A newly developed educational program was designed to promote critical discourse and discussion on complex climate change and renewable energy issues, targeting chemistry students in 9th-12th grade. The program combines the use of data and chemical knowledge to address dilemmas in the context of these environmental issues. The program was designed to enable students to understand various aspects of the issues through a gradual and continuous learning process. The purpose of this study was to investigate the

program's impact on the development of the participating students' critical thinking and argumentation skills. The sample consisted of 300 chemistry students in 9th-12th grade who were divided into an experimental group that underwent the program as well as a control group. The research is based on mixed methods (qualitative and quantitative) and PRE-POST questionnaires that explore changes in students' critical thinking ability when they read scientific articles. The initial results of this study indicate that the initial level of students' critical thinking skills was low. Since we are still collecting data, we will be able to present in the poster the impact of the program on the student.

Parallel Session - 5.6 (Posters)

16:00 - 17:30 Tuesday, 29th August, 2023

Chair: Maija Aksela

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470 Investigating the Interconnectedness of Knowledge in Concept-Maps in Science Teacher Education

Dominik Diermann, Jenna Koenen

Technical University of Munich, Munich, Bavaria, Germany

Abstract

It is crucial that teachers possess the professional competences to link subject-knowledge with education ideas and concepts to secure qualitative and effective lessons. Meaning they not only need a high level of content, pedagogical-content, and pedagogical knowledge, but these also need to be interconnected. However, there are different problem-fields in German university education leading to a too low level of interconnected knowledge. Therefore, this project introduces ideas to support teacher education in general and establish stronger connections between the subject of chemistry and chemistry education. Presented is one approach to measure and reinforce pre-service teachers' interconnected knowledge in a university seminar. To do so a revision-course for students in their last semesters to prepare themselves for their final exams was offered. During this seminar students answered questionnaires on their personal estimations on the importance and perception of networking at the university and in their future life. In a pre-post-designed study, they also drew concept-maps and used the think-aloud-method to express the current level of their knowledge and its interconnectedness before and after the seminar. We were also interested in the question in how far concept-maps generally are suitable for a visualization of the interconnectedness of knowledge in this context. Results indicate that students have a quite high level of knowledge but need more support to connect those isolated concepts and ideas. Although they have difficulties to express their cognitive schemes in a connected way in the concept-maps. In addition, they estimate the interconnectedness of knowledge as very important for their future profession as science teachers. In the future, the project therefore, aims to establish ways to help students in this

regard and support their coherence experience during the university education to address this problem field.

416 Crafting the 21st-Century Preschool Teachers: Designing Inclusive Science Learning Environments

Angelos Sofianidis[1], Nayia Stylianidou[2]

[1]University of Western Macedonia, Florina, Greece. [2]Frederick University, Nicosia, Cyprus

Abstract

The current study presents a course design for preschool student teachers on science education based on the challenges of a continuously evolving world. This world involves the request for more inclusive environments that will offer meaningful and challenging learning opportunities to all students as well as students who are raised in an interactive immersive and digital context, expecting similar experiences in their learning experiences. To meet these new realities and needs, teachers need not only to be prepared for designing and developing inquiry-based activities but to design them by considering those emerging needs. Based on that, a Science Education course was designed that includes an introduction to inquiry-based learning activities design, Universal Design for Learning, Alternate Reality Games, and Augmented Reality technologies. During the presentation, we will present some initial results from the data collected during the spring semester 2022-2023 regarding the learning outcomes and students' perceptions of inclusive science education.

196 The Influence of Early Childhood Student Teachers' Beliefs on their Intention to Use Inquiry-Based Learning Methods

Anastasios Zoupidis[1], Vasilis Tselfes[2], Petros Kariotoglou[3]

[1]Department of Primary Level Education, Democritus University of Thrace, Alexandroupolis, Greece. [2]Department of Early Childhood Education, National and Kapodistrian University, Athens, Greece. [3]Department of Early Childhood Education, University of Western Macedonia, Florina, Greece

Abstract

In this study, we investigated early childhood student teachers' beliefs (N=81) that might influence their intention to use inquiry-based learning methods due to a six-month science course. The research was carried out in a Department of Early Childhood Education in Greece. Understanding of the inquiry-based method was assessed with an open- and closed-ended questionnaire. Their intention to use the method in their teaching was investigated in the context of the Theory of planned behavior with a 36-task Likert-type questionnaire. According to the Theory of planned behavior student teachers' intention to use inquiry-based learning methods is influenced by social factors (attitude, normative and control beliefs). The results revealed high intention, although differentiated, to use inquiry-based learning methods due to student teachers' participation in the six-month science course. Specifically, student teachers'

intention is supported by the positive control estimate of their engagement with the method and impeded by estimates of the opinion of significant others (normative) as well as the assessment of the balance of personal gains-losses (attitude) expected from their involvement with the inquiry-based method.

85 Putting the Pieces Back Together: Recomposing Elementary Science Teaching Practices

Marti Canipe

Northern Arizona University, Flagstaff, AZ, USA

Abstract

Elementary teacher educators endeavor to prepare prospective elementary teachers to teach science in ways which best support student learning. One framework which has been used in many teacher preparation programs consists of three-parts: representation, decomposition, and approximations of practice. In this study I examined the science teaching practice of three student teachers enrolled in the same teacher education program to understand how they enacted teaching practices from their teacher education coursework. Findings showed that each student teacher adopted a different, singular practice as their primary guide for teaching science rather than a more integrated approach. This suggests that a more explicit focus on recomposition of practice is a necessary part of teacher education.

1161 The Teaching of Sciences/chemistry in the Brazilian Context

Paulo Vitor Teodoro[1], Elisabete Gonçalves[2], Ivna Di' Moura Rodrigues[2], Nicéa Amauro[1]

[1]Federal University of Uberlândia, Uberlândia, Minas Gerais, Brazil. [2]Goiás Federal Institute, Urutaí, Goiás, Brazil

Abstract

This paper seeks to analyze two different types of basic education in Brazil: Regular High School (ER) and Youth and Adult Education (EJA, in Portuguese). As a proposed methodology, qualitative research of a documental nature was used. As for the procedures, we carried out the application of questionnaires to students who are in the last year of Basic Education (3rd grade of High School), from a public school in the State of Goiás, Brazil. We infer, from this research, that EJA students have a greater conceptual gap in Science, when compared to RE students. Thus, we believe it is necessary to rethink the adoption of pedagogical practices that value the particularities that exist with EJA students. However, in both modalities, there is a need to resume the discussion about the purposes of teaching Science/Chemistry, since basic education, as it has been carried out in Brazil, has distanced students from the main objective of teaching Science /Chemistry: forming critical citizens for the exercise of citizenship

694 The Changing Face of Science Outreach - a Policy Review

Maurizio Toscano[1], Jan van Driel[2], Victoria Millar[2]

[1]The University of Melbourne, Melbourne, Australia. [2]The University of Melbo, Melbourne, Australia

Abstract

In recent years, policies aiming to improve the relationship between science and society have led science organisations across the globe to invest heavily in science outreach. Outreach programs typically target young people, allowing participants to engage with contemporary science ideas and practices, and to interact with scientists. On the basis of an analysis of policy documents and research publications, this paper demonstrates how the emphasis on outreach and the range of purposes that science outreach programs seek to achieve has changed over time. A growth of such programs can be seen in many countries in recent decades as outreach becomes increasingly incentivised both by expectations that scientists engage more actively with communities and as a result of outreach being linked to competitive research funding. However, very little is yet understood about the complex web of influences science outreach has on its participants.

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375 The Science Education of Missionaries in China: From 1870 to 1929

Junye Gao, Tetsuo Isozaki

Hiroshima University, Higashihiroshima, Hiroshima, Japan

Abstract

This study provides a historical sketch of the science education of missionaries in China. It seeks to answer two research questions: (1) What were the characteristics of the science of missionaries? (2) Why did they teach Western science in China? By analysing records of meetings held by missionaries and journals published by missionary associations, we found that natural theology based on the Bible was the main feature of the missionaries' science. In addition, the word 'science' in missionary schools is closer in meaning to the episteme mentioned by Aristotle than to a subject in the modern sense. Moreover, science teaching at the end of the 19th century was part of the mission of missionaries, while at the beginning of the 20th century, the wave of modernisation in China forced missionaries to introduce Western ideas of science education to compete with government schools, which focused on the epistemological value of science not just the acquisition of scientific knowledge.

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276 An Analysis of Chinese Chemistry Curriculum Standards Based on OECD Education 2030 Curriculum Content Mapping

Xiaoge Chen[1], Xin Shao[2], Lei Wang[1]

[1]Beijing Normal University, Beijing, China. [2]Educational Science Publishing House, Beijing, China

Abstract

This paper compared both 2011 and 2022 chemistry curriculum standards based on Organization for Economic Co-operation and Development (OECD) 's future education and skills 2030. A mixed research method of qualitative and quantitative analysis was conducted to explore the characteristics of Chinese chemistry curriculum structure, and curriculum alignment levels with OECD learning framework 2030. A total number of 1020 coding units were analyzed. The Curriculum Content Mapping (CCM) was used to explore the relevance of 28 OECD competencies with the Chinese Compulsory Chemistry Curriculum Standards. The CCM heat map gave an overview of the accordance of Chinese compulsory curriculum standards with OECD competencies, which shed light on Chinese ten years of curriculum development. Results showed that both CCCS fitted the future competency suggested by OECD, with the new CCCS showing more advanced alignment. This study provides potential opportunities for future curriculum development.

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149 Characterization of Immunology Contents Demanded to Basic Education Students and Teacher Trainees in Two Brazilian National Exams

Pedro Augusto dos Santos Silva[1], Pedro Emilio Marinho[2], Patricia Marzin Janvier[3], Daniel Manzoni de Almeida[3]

[1]FMU, São Paulo, SP, Brazil. [2]Western University, London, Canada. [3]UBO, Brest, Bretagne, France

Abstract

Immunology is an important knowledge for the exercise of citizenship, especially after the beginning of the COVID-19 pandemic. However, what are the specific immunology contents demanded throughout the formation processes and how are they articulated? We analyzed the presence of immunology questions in two national exams (ENEM and ENADE) held in Brazil. The analyses showed the presence of questions that demand immunology knowledge in the basic and higher education levels, with a predominance of the articulation of this scientific knowledge with technology and society. However, there is little articulation of this knowledge with other processes related to the nature of science that are important for critical development and scientific literacy.

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139 The Emergence of 'Science for Excellence': A Historical Case Study of Japan's Education System

Tetsuo Isozaki[1], Takako Isozaki[2]

[1]Hiroshima University, Higashi-Hiroshima, Hiroshima, Japan. [2]The University of Toyama, Toyama, Toyama, Japan

Abstract

This study aimed to distil important historical lessons from 'science for excellence', which was initiated with an intention to provide science education to gifted and talented students. Although Japan was hostile towards the United Kingdom and the United States during World War II (WWII), they conducted a 'special science education' (SSE) research project, known as 'science for excellence'. This research project was based on an initiative by the Ministry of Education at the end of WWII, targeting gifted and talented students in science and mathematics fields in primary and secondary schools. Despite being a short-lived experiment, the SSE project provides valuable historical perspectives, such as the importance of defining 'gifted and talented students' and teacher education clearly.

Parallel Session - 5.7 (Posters)

16:00 - 17:30 Tuesday, 29th August, 2023

Chair: M. Gabriela Lorenzo

965 Effectiveness and Inclusivity: Determining Best Physics and Astronomy Departments for Women of Colour

Jaimie Miller-Friedmann, Nicola Wilkin

University of Birmingham, Edgbaston, United Kingdom

Abstract

Women of colour (Black, Asian, and Minority Ethnic (BAME) women) are underrepresented in particular science disciplines at the undergraduate level, including physics and astronomy. However, there has not been any research done on where BAME women do attend university in these fields, and the factors that may contribute to their choice to attend and graduate from certain physics and astronomy departments. This qualitative study uses data from several sources to create an 'effectiveness score'; the effectiveness score shows that the departments that are best at recruiting, retaining, and graduating BAME women in physics and astronomy are a diverse set of institutions which maintain robust academic standards and actively promote inclusivity. We present these data as an invitation to the physics education community to use as a stepping stone to begin more in-depth discussions of current practice and student participation, in order to better approach equity and diversity.

838 Attitudes of Turkish Immigrant Students Towards Science in England From a Cultural Perspective

Havva Görkem Altunbaş

Turkish Ministry of National Education, Ankara, Turkey & University College London Institute of Education, London, United Kingdom

Abstract

This mixed-method research aims to investigate immigrant Turkish students' attitudes towards science regarding their intangible cultural heritage, such as parental traditions, home language and ethnicity. The study is grounded on the role of cultural capital of Turkish secondary students living in England in their science-related aspirations. The combination of Reci and Dyan's self-determination theory and Bourdieu's work on capital constructs the theoretical framework of this study. The study utilises a mixed-methods approach. A questionnaire has been designed and used in a pilot to examine the range of factors that might affect immigrant students' science attitudes. This questionnaire will be used with roughly 100 years eight and nine Turkish immigrant students in England. In the second phase of data collection, based on the answers to the questionnaire, semi-structured interviews will be held with approximately 15 students and their parent(s) to gain deeper insight into how students' motivations towards science are shaped by their social and cultural capitals. The thematic analysis will analyse the qualitative data. The pilot findings show that second-generation immigrant students state that they do not want to continue to study science, citing a lack of perceived competence. On the other hand, first-generation immigrant students state that they are eager to study science despite their low sense of competence in science. The main phase of data collection phase is now underway. By the time of ESERA 2023, data analysis will have largely been completed.

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617 Science Education and Citizenship: Which Citizen for Which Society?

Bruna Herculano, Carolina Rodrigues de Souza

Federal University of São Carlos, São Carlos, São Paulo, Brazil

Abstract

Discourses and reflections on the educational context often bring the idea of an education for citizenship that sometimes aims at a "model" of citizen for an idealized social environment. Due to its polysemic character we cannot state that different interlocutors speak of the same citizenship when using this same word. In the context of science education, citizenship education intends to form individuals capable of understanding, questioning and transforming the reality that surrounds them. However, little is addressed on what conception of citizenship is thought to be worked by education and in what conception of society this projection will operate. This work is part of doctoral research in development and aims to discuss theoretically which citizen for which society? The text is structured by a brief explanation on how the conception of citizenship is allied to the conception of society. In a second moment we present the conception of citizenship that permeates the context of Science Education. It is possible to

notice the homogeneous and superficial sense of the use of the term, becoming insufficient to contemplate the plurality that permeates the educational field and the current social context. After understanding how this concept is socially constructed and used by Science Education, we propose that to deepen the discussions involving citizenship, dialogue with theoretical references related to post-structuralism, cultural studies and decolonisation. Such theoretical contributions may contribute to problematize and expand the margins of the model of citizen that permeates scientific education.

584 Differences of Disciplinary Identities of Upper Secondary School Students

Jonas Niemann

University of Copenhagen, Copenhagen, Denmark

Abstract

In science education research, the concept of 'science identity' has worked as a powerful analytical tool to describe and understand the imagined future selves and educational choices of students. This study extends science identities by investigating their various disciplinary-specific identities, by analysing students' perceptions of different science contents, cultures, and disciplinary recognition practices in their school subjects Mathematics, Chemistry, Physics and Technology. Data is produced in three Danish upper secondary schools and includes ethnographic classroom observations and group interviews with students. The schools and classes were selected to present a diverse group of students from different backgrounds, who have all chosen STEM subjects at a post-compulsory level. Preliminary data shows that students are capable of empirically ranking subjects rather coherently on Biglan's dimensions and a cooperative dimension, except for Technology. Discussions from interviews and classroom observations further show that Technology is hard to categorize and works notably different than the other subjects, and that gender differences are more pronounced here. Notably, a gender difference in the values of students' thoughts on further education is not present, emphasising that the gendered choice of education might not be value-based.

506 Two Multilingual Students´ Enactment of Agency in Discussions About Science

Pauline Book

Inland Norway University of Applied Sciences, Hamar, Inland, Norway

Abstract

This case study investigates the enactment of agency by two 11-year-old multilingual pupils when they write about and discuss science. Both came from immigrant families and were learning Norwegian as their second language. One of the pupils was born in Norway, while the other one had attended Norwegian school for two years. The study investigates two researcher-initiated activities to gain insight into how the two informants use language and everyday experiences to act in subject-specific discussions with peers. The pupils in a fifth-grade class

were encouraged to use their everyday experiences and could themselves decide whether they want to write words, draw, make figures or combine these modes of expression in so-called 'identity texts'. The two multilingual informants then separately participated in a series of four discussions with a peer and the researcher about a science topic, using their identity texts as a basis for the conversations. The pupils' enactment of agency was analysed by categorizing initiative through turn-taking in the discussions, together with a combination of ethnographically inspired interpretations of identity texts and the pupils' involvement in those discussions. The findings indicate that an open-ended approach to the subject matter lays a foundation for pupils to use resources formed through language and experiences. The identity texts contribute to pupils being able to link their own experiences with the subject matter. Further, the study shows that silence among the multilingual pupils in focus here is not indicative of passive participation in classroom discussions. The findings illustrate that inclusive teaching practice is needed for multilingual pupils who are simultaneously learning school subjects and the classroom language, so they better may enact agency in science discussions in the classroom.

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464 Am I a Scientist? Girls Doing Identity Work in Upper Secondary School Physics – a Critical Feminist Gender Study Using Science Identity as an Analytical Lens

Morten Stummann

University of Copenhagen, Copenhagen, Denmark

Abstract

Using mixed methods this study explores young women's identity work performing science identity within a physics extensive upper secondary study programme. The data are based on survey, ethnographic fieldwork and interviews conducted at six different upper secondary schools in Denmark. The study shows that halfway through upper secondary school most of the young women perform a science identity having physics as a favourite subject, having a feeling that they are good at it, that they belong within physics, and that they can imagine themselves within science in the future. By focusing on the educational context, the study also shows narratives circulating within upper secondary school reproducing the cultural heritage of associating physics with being male and thereby othering female students by articulating them as passive, uncertain of their abilities, needing help and encouragement, and not looking like the standard female upper secondary student.

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218 "Natural Brilliance"? Young People's Construction of the Ideal Student in Computing

Billy Wong[1], Meggie Copsey-Blake[2], Jessica Hamer[2], Peter Kemp[2]

[1]University of Reading, Reading, United Kingdom. [2]King's College London, London, United Kingdom

Abstract

Computer science and the technology industry is frequently portrayed in popular discourses as individuals who are highly skilled and tech-savvy, contributing to stereotypes that can potentially exclude those who lack these skills or traits. Such preconceptions can have an impact on young people's educational and career aspirations, particularly if there are gaps between their own identities and expectations for computer science students. Based on data from an open-ended questionnaire of 4,900+ young people in England (aged 11-16), we analysed 9,000+ keywords that students used to describe their 'ideal student' in computer science education. This paper presents an innovative large-scale descriptive analysis of the most frequent words used by students to describe the ideal computer science student, which will also be analysed by student demographics such as gender. We have provisionally identified eight 'groups' of ideal traits for computer science students, namely being 'smart & clever'; 'knowledgeable & interested'; 'determined & hardworking'; 'friendly & helpful'; 'creative'; 'independent'; 'confident & funny'; and 'cooperative'. By understanding how students imagine the ideal computer science student, we can better appreciate their educational aspirations, choice of study and the possible influence of wider discourses and social factors.

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368 Improving Teachers' Science Media Literacy Through Workshops

Huei Lee, Cha-Ling Chiang

Department of Education and Human Potentials Development, Hualien, Taiwan, Taiwan

Abstract

This study, based on the results of previous research (Author & Author, 2022) and Hobbs' (2010) recommendations, designs a science media literacy (SML) course to explore the changes in teachers during a three-day workshop. A total of 12 participating teachers were included in the course, which covered media literacy and food safety issues (genetically modified food and food additives), using strategies such as information search/evaluation, cross-media comparison/reading, and group discussion to develop suitable SML courses for students. Data collection included discussion records, interviews, and practical documents as qualitative data, and thematic analysis was used to summarize the research findings. The results showed that teachers had positive changes in media literacy, food safety issues, and pedagogical SML knowledge, and that combining argumentation and inquiry-based implementation can effectively enhance teachers' SML. The greatest key to the willingness of teachers to try teaching changes and reflect on their own was their personal willingness and willingness to learn. Through teachers' changes, the community of science education can expand the role of science education and education in broader social contexts, and it seems that it can benefit the improvement of science literacy for all people.

Parallel Session - 5.8 (Posters)

16:00 - 17:30 Tuesday, 29th August, 2023

Chair: Lilia Halim

1165 Inclusive Science Education in Cultural History Museums: Museum Educators' Perspectives

Senem Bas

George Mason University, Fairfax, VA, USA

Abstract

Although inclusion becomes a topic that is receiving substantial attention in science education research and museum studies, the research to date has given limited attention to gathering data from the museum educators' perspectives and studying their experiences on inclusive science education. This research study aims to fill this gap by conducting in-depth interviews with three cultural history museum educators and exploring their experiences and perspectives on inclusive science education and necessary trainings for museum educators. Five key findings emerged from the analysis of the data: (1) museums need to provide accessible curatorial, educational, and technological and universal design practices for better science learning (2) Linguistic diversity has a positive effect on how multilingual audience can engage and get motivated in science learning (3) Social inclusion is an important leg of inclusive science learning and visitors must be integrated into the museum's identity and programs (4) Museums have not been able to diversify their workforce enough and they need to represent the diversity of their audience in their staffing. (5) Lack of financial support is the biggest challenge in developing professional development trainings in inclusive science teaching but with having the right mindset, and benefiting from local organizations and resources a lot can be accomplished.

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953 Preparing an Out-of School STEAM Curriculum for 12-14 Year Old Girls

Maria Evagorou, Elisavet Pitri, Agni Stylianou

University of Nicosia, Nicosia, Cyprus

Abstract

The need to engage girls from a younger age in STEM in order to increase their interest in the fields and empower them is highlighted in many recent reports. Furthermore, integrated STEM and STEAM are not easy to implement in formal school settings because of the rigid boundaries between disciplines. Starting from the aforementioned gaps we designed an out-of school STEAM curriculum to empower and aspire 12-14 year old girls. In this paper we reflect on the process of designing and implementing the curriculum. The first cycle of the curricula was designed and implemented for a four-day summer school that took place during in 2021. Based

on findings from the first year, a new version was designed and implemented in 2022 with 27 participants. Students changed their views positively about engaging in STEM and reported that they understand how STEM can help them in their future careers and their everyday life. Lessons learned from the process of designing and implementing the curricula were related to using a driving problem to guide activities, introducing activities that promote students' interests, explaining and engaging students with the design process, and adding entrepreneurship activities.

857 Development of the Workshop Integrating Science and Dance Supposed for Informal Learning Settings Such as Science Museums

Aoi Takahashi

Kobe University, Kobe, Hyogo, Japan

Abstract

Arts integration has received increasing attention in recent years. This study develops a workshop for children on integrating science and dance in informal learning settings. Although research has been conducted on integrating science and dance in school education, there needs to be more research on integrating science and dance in informal learning settings. This study will explore its application to informal learning settings such as science museums. We are developing a workshop integrating science and dance for children, supposedly for informal learning settings such as science museums. The workshop is aimed at primary school children. The topic of the workshop is the life of stars. The workshop consists of four parts. Through the workshops, children learn the definition of a star, that a star's lifespan is determined by its mass, the changes from birth to death of a star, its colour, and its surface temperature and elements universal to all dance: Body, Energy, Space and Time. This paper describes the proposed design of the workshop and survey method. The workshop will take place on a small scale in February 2023 and will be improved through workshop participants and stakeholder surveys.

833 Bringing Education Outside the Classroom; Benefits, Challenges and Pathways Forward

Deirdre O'Neill[1], Orla McCormack[1], Regina Kelly[1], Nathália Helena Azevedo[2], Lucy Avraamidou[2]

[1]University of Limerick, Limerick, Ireland. [2]University of Groningen, Groningen, Netherlands

Abstract

This study presents findings from a systematic literature review exploring Education Outside of the Classroom (EOC) practices. EOC was characterized by curriculum-based educational activities practiced outside the school building, in natural (e.g., a park or forest) or cultural (e.g., a museum or library) settings. The aim of this systematic review was to identify, organize, and synthesize empirical research into the impacts of EOC practices on students (aged 6-18 years) in terms of cognitive, affective, and psychomotor outcomes; gender and geographical

differences; methodologies for assessing impacts; and effective tools and practices used by EOC practitioners to achieve positive impacts. This study highlights the importance of creating a repertoire of education outside the classroom practices that captures the unique contexts in education that are created by our diverse student population. Findings from the study suggest that education outside the classroom can, in fact, help to connect science education to cultural heritage by engaging students to learn in, forests, beaches, mountains, museums, libraries and many more EOC sites. The study outlines the aspects of research that are yet to be investigated and suitable approaches (collection of longitudinal data) to examine the long-term effects of adopting an education outside the classroom approach. This study forms part of a EU Horizon 2020 funded project.

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571 Out-of-Classroom Science Education in Europe: A Mapping Study of Practices and Paths to Accreditation

Nathália Helena Azevedo[1], Deirdre O'Neill[2], Orla McCormack[2], Regina Kelly[2], Lucy Avraamidou[1]

[1]University of Groningen, Groningen, Netherlands. [2]University of Limerick, Limerick, Ireland

Abstract

Research interest in science education outside the classroom (EOC) has received increased attention in the last few years in response to the need to provide education connected to contemporary socioscientific challenges. Formalising EOC practices involves discussing accreditation processes for initiatives that expand learning possibilities regarding curricular demands and resources. Accreditation procedures can ensure the quality of education as well as the safety of students. This paper presents the results of a mapping study aimed at contributing to the understanding of how EOC is structured in various countries in Europe to assess gaps and opportunities to further the discussion about introducing an EOC accreditation framework. Following a systematic mapping methodology, we analysed 65 papers and 187 initiatives, spaces and programs used for EOC activities. Regarding curriculum, we identified a predominance of biology content, student-centred pedagogical approaches implemented in multiple sessions, and EOC activities in parks and museums. We also identified a significant lack of information on (i) the degree of curriculum alignment of EOC programs with country-specific curriculum parameters, (ii) learning assessment processes, (iii) the professional qualifications of staff involved in EOC initiatives, and (iv) children's school needs in terms of accessibility, inclusion, and safety. Nevertheless, the variety of mapped practices can contribute to advancing discussions about good EOC practices and thinking about ways to accredit EOC. This study forms part of the EU-Horizon 2020-funded project OTTER (Outdoor Science Education for a Sustainable Future).

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38 School Science Clubs: What is Their Value for Teachers?

Jorge Martín-García[1], Ana Afonso[2], María Eugenia Dies Álvarez[1]

[1]Universidad de Zaragoza, Zaragoza, Aragón, Spain. [2]Universidade do Minho, Braga, Braga, Portugal

Abstract

This study aims at identifying the value that science teachers, responsible for these settings, attribute to science clubs. We present the data from a semi-structured interview with eight teachers. Data was analysed using Bell's framework, which was complemented with a bottom-up analysis of the data. Results suggest that teachers' value the clubs for students, which are consistent with Bell's framework, for the educational community, and for their professional development. They did not mention the value for the partner institutions. In summary, the clubs were also seen as unique in terms of the opportunities they provide to discover science and reflect on its nature and its role in society.

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23 "More than robots": Reviewing the Impact of the FIRST LEGO League Challenge Robotics Competition on Students' STEM Attitudes, Learning, and 21st-century Skill Development

Michael Graffin, Rachel Sheffield, Rekha Koul

Curtin University, Perth, WA, Australia

Abstract

The international FIRST® LEGO® League (FLL): Challenge is a popular educational robotics competition involving over 318,000 students (aged 9-16 years) in approximately 110 countries. This presentation will explore the findings of Graffin et al.'s (2022) semi-systematic historical review of the FLL research literature examining the competition's impact on students' STEM attitudes, learning, and twenty-first century skills. Reviewing 26 publications between 2004 and 2022, the authors identified the emergence and development of three significant historical research themes: (1) impacts on students' motivation, STEM learning, and attitudes, (2) development of twenty-first century skills, and (3) coaching/pedagogical strategies to support student learning and skill development. The first theme was further refined through three sub-themes examining impacts on female participants, ethnic minority groups, and students with special needs. International research findings regarding competition on students' motivation, STEM attitudes, and learning were positive for all student groups, especially female participants, but were not always statistically significant. Findings regarding positive short-term impacts on twenty-first century skill development were broadly consistent, but long-term impact findings were inconclusive. The influence of coaches' skills and pedagogical expertise upon students' learning and skill development in the FLL Challenge is a potentially underrepresented area of research.

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322 Stories in Relation to Power and Privilege: The Experiences of Racialized Students in STEM Education at a Western Canadian University

Kristal Turner

University of Calgary, Calgary, Alberta, Canada

Abstract

The experience of racialized students in university is an area that is not well understood in Canada, due to the lack of data and concerns brought up by racialized students today. Postsecondary education is a time of transition and critical identity development, and identity can be a beneficial lens to understand racialized student experience in postsecondary education. The purpose of this ethnographic research aims to bring attention to the experiences of racialized students in terms of the racism, lack of safety, profiling, and microaggressions they still face. Five themes were noted as common narratives during the data analysis: Representation/Recognition, Emotional Labour and Emotionality in Science, Safe Spaces, Geographical and Historical Identity, and Navigating University Norms. These themes are then used to offer some insights and interpretations that can be used to improve the experiences of racialized students at postsecondary institutions.

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15 Emergency Science Teaching During the Covid-19 Pandemic: Tales from the Front Lines

Banu Avşar Erümit[1], Sumreen Asim[2], Valarie Akerson[3], Claire Cesljarev[3]

[1]Recep Tayyip Erdogan University, Egitim Fakültesi, Cayeli, Turkey. [2]Indiana University Southeast, New Albany, IN, USA. [3]Indiana University, Bloomington, IN, USA

Abstract

Around the world COVID-19 caused havoc in many settings, not the least of which was in education. In this paper we explored United States K-12 teachers' responses to Covid 19 emergency instruction, middle school science teachers in Turkey, and elementary and secondary methods instructor responses to emergency COVID-19 instruction. Similar to a natural disaster, the COVID-19 pandemic set off a series of adverse events. For example, a high-magnitude earthquake initially exposes one to destructive quakes and aftershocks but subsequent secondary stressors can also be debilitating as survivors grapple with losing their homes, insurance difficulties, and stalled rebuilding efforts. Unmet mental health needs after a disaster were major disturbances for university staff persisting to fulfill academic, teaching, clinical and administrative roles after one such earthquake (Bell, et al., 2016). COVID-19 caused major shifts in instruction and stressors on teachers at all levels. How could we pivot to online teaching? Would our students still learn? It was concerning for science educators who were accustomed to teaching using hands-on inquiry instruction. How could students manipulate materials in virtual settings?Data were collected at four sites—K-12 teachers in the U.S., middle schools in Turkey, and U.S. elementary and secondary methods courses. Data analysis showed that teachers at all levels struggled and were impacted, but in various ways.

Parallel Session - 5.9 (Posters)

16:00 - 17:30 Tuesday, 29th August, 2023

Chair: Hsin-Kai Wu

1312 ICSE Science Factory: An Open Schooling Project

Semra Akgönüllü[1], Çağla Süslüay[2], Gultekin Cakmakci[1], Gokhan Kaya[3], Metin Sardag[3], Buket Akkoyunlu[3], Katja Maass[4]

[1]Hacettepe University, Ankara, Turkey. [2]Önce Öğretmen Vakfı, Ankara, Turkey. [3]Hacettepe STEM & Maker Lab, Ankara, Turkey. [4]University of Education Freiburg, Freiburg, Germany

Abstract

What does Open Schooling mean? We want to open schools and network them with external partners, working together with families and interested citizens on an equal footing. At school, we want to work on socially relevant topics to find concrete solutions to real-life problems in our own city or region. How can this happen? During 2023-2026 ICSE will work together with partner schools and experts from science, companies and non-formal education providers. Together, our Science Factory team will build regional networks and together design a variety of innovative and creative hands-on activities. We will also organise a series of career talks where students can get to know (female) role models from exciting STEM professions first-hand. Twice a year, there will also be a big interactive fair where all participating partners and projects can present themselves, exchange ideas and have fun together. You can also look forward to our new Science Lab: From autumn, you can try out exciting activities here: 3D printing, escape rooms, forest experiments and much more.

1011 ICSE Academy-ProSTEM: European Cooperation and Mobility in the Professional Development of STEM Teachers

Mehmet Sogut[1], Metin Sardag[2], Gultekin Cakmakci[3], Katja Maass[4], Maria Evagorou[5]

[1]Fatih Sultan Mehmet Middle School, Aksaray, Turkey. [2]Van Yuzuncu Yil University, Van, Turkey. [3]Hacettepe University, Ankara, Turkey. [4]University of Education Freiburg, Freiburg, Germany. [5]University of Nicosia, Nicosia, Cyprus

Abstract

Professional development, collaboration, and mobility factors might improve Europe's STEM education systems, enable STEM teachers to successfully become lifelong learners in the European education area, and develop deep-rooted motivation to minimize the number of low-performing STEM students. The project, entitled "Professional Development for European In- and Pre-Service STEM Teachers (ICSE Academy-proSTEM)," focuses on the factors mentioned

and the following key pathways to building a highly qualified STEM teacher workforce. (1) development of new tools for the professional development of pre-service and in-service STEM teachers; (2) increasing the attractiveness of the teaching profession. (3) promoting mobility in STEM initial teacher training and continuing professional development; and (4) instilling confidence and competence in the use of technology. (5) Incorporating research findings into policymaking processes; (6) Fostering innovation based on available resources (and best practices). The project offers a wide range of activity formats, such as reflective professional training for educators and teachers through a series of online trainings on relevant focal topics, grouped workshop series, and summer schools that bring together in-service and pre-service STEM teachers and STEM educators.

300 Integrating Corubric with Gamification of Resources in Science Education

Daniel Cebrián-Robles, María José Cano-Iglesias, Paloma España-Naveira, Antonio Joaquín Franco-Mariscal

Malaga University, Malaga, Spain

Abstract

This paper shows an example of integrating the CoRubric assessment tool in an experience of designing gamified resources in science education with 43 pre-service science teachers from the University of Malaga (Spain). Participants had to design a gamified resource to teach science to secondary school students and explain it at a science fair. In addition, they had to design an e-rubric to evaluate the gamified resources made by their peers. Participants could improve their e-rubric design throughout the experience; on the one hand, by comparing it with that of their peers and, on the other hand, after attending the explanation of the different resources. This work analyses the participants' perceptions of the design and use of e-rubrics, finding significant progress in their design and gamified resources. Also, emotions of interest and concentration emerged during the experience.

1298 InspirING® Pupils for STEM – a Project Overview

Corinna Eußner

University of Applied Sciences Karlsruhe, Karlsruhe, Germany

Abstract

As in some other countries, the lack of skilled workers in the STEM sector is a current and future problem in Germany. In addition to the effects of the 4D megatrends, this is also due to the decline in the number of first-year engineering students and the interest and perception of STEM professions in society. To counteract this, the InspirING® project was launched at Karlsruhe University of Applied Sciences in 2019. Engineering and STEM students prepare and perform an experiment for a school class that reminds the students of a special course content during their study: The aim of this elective is to arouse students' interest in technology through performative learning and didactic analysis with a low-threshold introduction. On the other

hand, science communication and soft skills of the students are trained. In addition to a list and overview of the framework conditions and previous implementations of InspirING®, a possible expansion is also presented.

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954 Supporting Student Teachers in Implementing Evidence-Informed Teaching Practices in STEM-Education

Ria Dolfing[1], Sabine Fechner[2], Pascal Pollmeier[2], Christian Bokhove[3], Sally Bamber[4], Eliza Rybska[5], Renata Dudziak[5], Adri Dierdrop[6], Lesley De Putter[7]

[1]Utrecht University, Utrecht, Utrecht, Netherlands. [2]Paderborn University, Paderborn, Germany. [3]University of Southampton, Southampton, United Kingdom. [4]University of Chester, Chester, United Kingdom. [5]Adam Mickiewicz University, Poznan, Poland. [6]DUDOCnetwerk, Amsterdam, Netherlands. [7]Eindhoven University of Technology, Eindhoven, Netherlands

Abstract

This presentation shares the results of the Erasmus+ project 'Research in Teacher Education (RiTE)'. The universities of Groningen, Southampton, Paderborn, Poznan and Chester, under the support of the DUDOCNetwork, jointly developed curricula to support students in implementing 'evidence-informed teaching practices'. The aim was to teach students how to use evidence from research in education and domain-specific fields of science, technology, engineering and mathematics (STEM) to improve their own teaching practices. Following a cyclical learning process of developing, implementing and evaluating curricula were developed using mechanisms of evidence-informed policy making. All universities conducted a case study in which they developed, implemented and evaluated their curriculum in their local initial teacher education (ITE) context. Data collection instruments involved a questionnaire, student test and interviews. Data analysis focused on getting insight into student teachers perspectives on, beliefs about and abilities in implementing evidence-informed teaching practices. This project resulted in five empirical validated curricula and in shared insights about student teachers who systematically use evidence to develop, implement and improve their lessons.

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891 Determining the Effect of Project-Based Science Education in Primary Students with Special Educational Difficulties

Aslı Nacar Işık, Betül Timur

Çanakkale Onsekiz Mart University School of Graduate Studies, Çanakkale, Turkey

Abstract

This study is planned to determine the effect of PBL (project-based learning) in primary school students diagnosed with SLD (special learning disability). This study, which is a qualitative research, can be defined as a Case Study model. In the study, interviews were held with the PDR (Psychological Counseling and Guidance) teacher of the students about the diagnosis of the students, records were kept by meeting with the families of the students and other course

teachers, the written grades of Science Sciences were evaluated, the students were observed in the classroom and extracurricular areas, and in a two-month period, the students were interviewed at the national level. prepared to participate in a project. In this process, it was applied with a structured interview form created by taking expert opinions. As a result, it has been determined that the Project Based Learning method has a positive effect on the academic achievement, attitudes and motivations of students with Special Learning Disability, as well as positive results in terms of adaptation to school and family life.

71 Role Reversal to Foster Perspective Taking on a Socioscientific Issue

Jen-Yi Wu, Ying-Shao Hsu, Fang-Ying Yang

National Taiwan Normal University, Taipei, Taiwan

Abstract

Perspective taking has been identified as a critical role in the resolution of multi-faceted socioscientific issues (SSIs). The purpose of this study was to explore the differences in effects of role play and role reversal on the development of perspective taking. High school students' comments and reflections on their positions in a web-based SSI module were coded to identify their perspective taking development. The results suggest that some participants were willing to consider incorporating opposite perspectives and to seek compensatory solutions. Moreover, role reversal was more effective than role play in fostering students' perspective taking on this SSI regarding the construction of a gas transportation station in a coastal area.

Invited Panel - 1

09:00 - 10:00 Wednesday, 30th August, 2023

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16 The Role of Science Education in The Post-Pandemic Context: Lessons Learned for Moving Forward

Chair

Gillian Roehrig

Discussant

Digna Couso, Peter Gray, Guia Bianchi, Olivia Levrini

Abstract

This invited panel discussion highlights international perspectives, taking varied positions, to examine the role of science education in light of lessons learned during the pandemic. We can argue that there has not been a time in recent history spotlighting the crucial role of science education in preparing a global society to understand the nature of scientific knowledge and enterprise and with abilities to engage in critical thinking about dynamic scientific information. The goals and pedagogies of science education are suddenly different. How the public and media understand and talk about socioscientific issues, sustainability, and scientific advances is quite telling with respect to scientific literacy. To these effects, in what ways was the pandemic a wake-up call for what and how we teach and talk science? The panelists will discuss driving forces for re-visioning, re-imagining, re-defining, and re-structuring science education. The discussion will center questions such as: How successful are education systems in preparing citizens for real-time, real-life socioscientific issues that not only disrupt, but change our reality? What lessons were learned with respect to policy, curriculum, sociocultural and sociopolitical pedagogies, nature of science, and connections across educational, technological, and societal contexts? What role do we, as a community of educators and researchers, have in the post-pandemic context for ensuring scientific literacy moving forward?

400 "Time Is Out of Joint": Re-Imagining Time Rituals in Science Teaching/learning

Olivia Levrini

Alma Mater Studiorum – University of Bologna, Bologna, Italy

Abstract

The pandemic has exacerbated an issue that was already deeply challenging society, science teaching, and science education research: "time is out of joint". We are living in "the society of acceleration" (Hartmut Rosa), and our educational systems tend to remain rigid and do not appear able to keep the pace of change. In the panel, I will focus on "time dissonances" in

school practices, that have been made more evident by the pandemic. Among them, I will specifically elaborate on examples of students' perceptions of time and examples of time rituals in science teaching/learning. Some research results on these themes will be the base for opening the discussion on possible roles that science education can play in the post-pandemic context.

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733 The "New" Meaning of Teaching Science

Digna Couso

Universitat Autonomous of Barcelona, Barcelona, Spain

Abstract

Teaching science has always been a complex task, even more so in the post-pandemic world. The COVID lockdown brought to light the challenges of teaching science in new and unprecedented ways. Online teaching, whether synchronous or asynchronous, posed additional difficulties, particularly for those teaching practices that despite having achieved consensus in science education research, are still not widely established in schools nor teacher education programs. Examples are challenges related to the phenomenon-based nature of science teaching; the promotion of students' participation in scientific practices; using productive discourse in the classroom to support student understanding; conducting formative evaluations to provide effective feedforward or taking into account affective factors to engage students' emotions and identities. While much of the current political discussion around post-pandemic teacher education focuses on digital competence and providing resources to schools, digital skills and resources are only a basic requirement. The real challenge of teaching science in a post-pandemic world is essentially the same challenge we have been facing: how to engage students and teachers in meaningful scientific learning in a way that helps them to recognize the empowering value of this knowledge. Despite not new, the importance of deep understanding of and about science rises in "the age of misinformation", where the ability to think critically about the emerging problems of our societies becomes crucial for our future (Osborne et al, 2022).

1323 Firing up Science Education: The Long Plume of S-TEAM and the Way to CONNECT

Peter Gray

Nord University, Levanger, Norway

Abstract

The Science-Teacher Education Advanced Methods (S-TEAM) project was funded by the EU under Framework Programme 7 (Project no. 834270) in 2009, and the CONNECT project (project no.872814) was funded under Horizon 2020 in 2020. Both these three-year projects were a product of the European Commission's desire to address perceived deficiencies in the

supply pipeline for scientific staff and a related lack of scientific literacy in the population at large, through implementing inquiry-based science activities in schools and elsewhere. The impact of such short-term projects can be measured in a limited way during their lifetime, but their medium and long-term impact is harder to gauge. This paper/presentation will suggest some possible methods for estimating such impacts, focusing first on the long-term impact of S-TEAM as manifested in policy changes, publications and emergent organisations. It will then examine the construction of short-term impact in CONNECT and how this might be extended and measured outwards in time. Impact is a contested concept and is especially hard to measure in education and social science projects, where there are few, if any, observable causal pathways between the implementation of a particular method of teaching and learning, and the desired outcomes of the project within the scope of the relevant EU work programme. However, there are many possible and desirable impacts over and above those mentioned in the official discourse. Through interviews, document analysis and extensive internet searches, the authors show that the scale and range of project impact may considerably exceed original expectations. We use our findings to suggest credible ways of modelling the medium and long-term impact of future projects in this and similar areas.

Plenary Lecture - 3 by William Cobern

10:30 - 11:30 Wednesday, 30th August, 2023

Chair: Mehmet Fatih Tasar

1304 Do We Trust Science?

William Cobern

Western Michigan University, Kalamazoo, MI, USA

Abstract

Do you trust science? Recently, the world has changed dramatically because of the Covid 19 pandemic. Obviously, there has long been a simmering trust problem that has now burst into the open. We science educators must ask about our responsibilities. Do we have a part in this problem? Have we played a role in creating the problem? Can we address the problem? Public trust in science is complicated and affected by many factors from religion and politics to science. In this plenary lecture, trust is the issue and these questions about trust are what I address. I report data from a previous study as well as studies more recently completed, all indicating that trust is problematic among students and may be connected to what science education teaches about the tentative nature of science. What we have found is that students are far more likely to say that science is tentative than the are to say that they trust science. Furthermore, when students are asked why it is they don't have more trust in science the typical answer is that science is tentative. My lecture concludes suggesting that it would be prudent for science educators to increase instructional focus on the relationship between data and

evidence that leads to the reliability of scientific knowledge (its durability), and thus to its trustworthiness. And, that future research needs to thoroughly investigate the public interpretation of what we teach about the nature and characteristics of science, such as tentativeness. We need to get beyond a focus on describing the nature of science to a focus on how what students come to understand about the nature of science influences their views on public policy where scientific knowledge is relevant.

73 Invited Symposium: Honoring the Legacy of Reinders Duit

Chair

David F. Treagust

Discussant

Jan van Driel

Abstract

This special symposium will honour the legacy of Professor Reinders Duit who passed away on 10 February 2023. Reinders was Professor of Physics Education at the Leibniz-Institute of Science and Mathematics Education (IPN) in Kiel, Germany. He was internationally known for his research and scholarship on conceptual change, students' conceptions of a broad range of core physics and science concepts, and as a co-developer and active promoter of the Model of Educational Reconstruction that enjoys enormous popularity from curriculum developers across the world. In this symposium, we refer to Reinders' enormous contributions in these areas of scholarship, as well as the developments and formation of ESERA, and his extensive supervision of graduate research students. As stated by Olaf Köller, the Managing Director of Research at the IPN, to IPN colleagues and others: "It is thanks to his many international publications and contacts that the IPN not only became well-known in the global science education scene but is still an excellent research institute today."

1307 Conceptual Change: The Search for an Organising Structure in Science Education

David Treagust

Curtin University, Perth, Western Australia, Australia

Abstract

My connection to Reinders was fortuitus. Having returned to Australia after PhD and post-doctoral studies in the USA, I worked at the newly created postgraduate program in science and mathematics education at what is now Curtin University. One of my tasks had been to write secondary and primary curriculum textbooks for teaching solar energy. With my wife Gisela, in 1983, I wanted to learn more about German science education research. At the IPN, I was introduced to Reinders because he was writing his Habitation on the energy concept. While his

work was so much different to the school curricula I had written, we learned we had other mutual research interests which led to our very successful research collaboration over 30 years on constructivist-informed teaching, the growing field of students' conceptions and, of course, conceptual change. Our most recent work was on multiple representations in science. I visited the IPN to work with Reinders on short and longer visits and Reinders made several visits to Australia and to Curtin University. Indeed, as others will attest, Reinders was well travelled and for many years the international face of German science education. It was always a pleasure to work with him. In this talk, I will discuss the wide range of Reinders' international collaborations, his many contributions to the literature, especially conceptual change, and his unique style of engagement with colleagues and graduate students, always underlined with a sense of joy and humour.

1308 Developing ESERA: The Contribution of Reinders Duit

Dimitris Psillos

Aristotle University of Thessaloniki, Thessaloniki, Greece

Abstract

During the 90's a new research association ESERA was developed in Europe. As the first president I am knowledgeable of the considerable efforts to put ESERA in action. In this capacity I was happy to cooperate with Reinders on several levels. Reinders contributed substantially on the thorough and extensive discussions and exchanges which were necessary for establishing ESERA as respective and attractive research association. In my presentation, I will refer to aspects of these actions and decisions. In particular, I will refer to the effective contribution of Reinders in the works of the Board and the organization of the second conference in Kiel, Germany in 1999. At that time, designing and organizing an ESERA conference had a risk which Reinders and the Germans colleagues undertook and carried out effectively. Reinders was a thoughtful and cooperative colleague concerning the works of ESERA. I was happy to discuss, cooperate and learn from him about science education research in addition to running our association.

1309 Internationalizing German Science Education Research

Knut Neumann

IPN–Leibniz-Institute for Science and Mathematics Education, Kel, Germany

Abstract

Reinders Duit was a remarkable researcher in many ways. His contributions to students' conceptions of major physics concepts, in particular the energy concept, were numerous; he supported a myriad of undergraduate, graduate and PhD students in their research; and helped build a science education research community. But one of his most remarkable achievements was probably his international visibility. He has published in many international journals, supervised many international students at the IPN, and served on the NARST Board.

He was the face of German science education research. Many identified the IPN with him. A fact that he always used to make German science education more visible. He drew on his networks to bring renowned science educators to Germany and to integrate German science educators into the international community. This service was recognized by the German Association for Chemistry and Physics Education through awarding him the first ever Medal for longstanding exceptional achievements in chemistry and physics education in 2008 and by NARST who awarded him the Distinguished Contribution Award in 2010. His engagement serves as an example for current and future generations of science education researchers.

1310 Mentoring Research Students With Great Skill and Passion

Dimitris Stavrou

University of Crete, Rethymno, Greece

Abstract

I first met Reinders in Thessaloniki in 1998. He was invited as a plenary speaker at the National Conference of the Greek Science Education Research Association. His presentation on the Model of Educational Reconstruction was so inspiring for me as a Master's degree student at that time, that I started to think seriously of continuing my studies at the PhD level at the IPN-Kiel. Finally, I started my PhD in September 2000 under the supervision of Reinders. We were nearly four years in close cooperation, which continued after my return to Greece. The Model of Educational Reconstruction, constructivistic approaches and conceptual change in science teaching, teaching experiments, non-linear systems, are some keywords which characterize his professional life and formed, also, my way of thinking about science teaching. During my collaboration with him, I have enjoyed the lively discussions and the exchange of ideas. He was not only an excellent advisor but also a very careful listener who shared the "concerns" of his PhD students and came up with solutions that helped the progress of our research work. He motivated us to take part in conferences and write articles for journals both at national and international levels. It was a great pleasure to introduce yourself as Reinders PhD student as he was well-known in the science education community, and a guarantee of high-quality work. My research work with Reinders opened not only for me but also for other PhD students of Reinders new opportunities in our academic careers.

1313 The Model of Educational Reconstruction

Ilka Parchmann

IPN–Leibniz-Institute for Science and Mathematics Education, Kiel, Germany

Abstract

The Model of Educational Reconstruction, which links science education research, instructional practice and teacher professional development, is one of the most important constructs in science education. And it is so because of Reinders Duit's close cooperation with science education colleagues and early-career scientists. Based on his intensive work on students´

preconceptions and his foundation of a first data base of these studies, long before the digital age, the MER reflected the value of preconceptions in a unique way—not as problems but as starting points for learning science concepts. While the well-known triangle version of the MER points out the iterative connection of the learners´ and the science perspectives for the design of a learning environment, the "Kiel version" of the model also highlighted several steps of analyses. The MER can sometimes be oversimplified. Reinders Duit had been aware of this risk and intensively discussed the quality criteria in all his presentations and papers. As one of the most outstanding scholars not only during his active time, but clearly until today, this presentation will honour Reinders Duit´s most impressive work on the MER which has influenced subject-matter oriented educational research and design far beyond the science subjects.

Parallel Session - 6.2 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

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30 A Systematic Literature Review of Physics Textbooks Focusing on - Curriculum Alignment, Content Analysis, Expectations and Evaluation

Chair

Marika Kapanadze

Discussant

Yaron Lehavi

Abstract

Physics textbooks (both print versions and their digital equivalents) play a critical role in the learning and teaching of students. They influence not only what and how students learn, but also what and how teachers teach. This Symposium discusses the four sections found in the chapter "Physics Textbooks" from the International Handbook of Research on Physics Education. This study provides a systematic analysis of the internationally-available, English-language literature about physics textbooks published in different journals, books, reports, and conference proceedings. The first presentation is about physics textbooks and curriculum alignment. A four-level view of the curriculum gives a good understanding of the place and potential roles that textbooks play in the educational processes. Examples from different countries provide an insight into textbook and curriculum alignment from different regions. The alignment of physics textbooks with meta-curricular frameworks and intra-curricular processes is also presented. The second presentation is about the content analysis of physics textbooks. In this review study, 138 research papers focusing on the contents of secondary and tertiary physics textbooks indexed on Scopus, ERIC and Web of Science between 1940 and 2021 are analysed. The authors categorized the analyzed papers into conceptual, epistemic, cultural levels of contents and the representations of the content in physics textbooks. The study also investigates how different methods of content analysis contribute to issues of physics textbooks

within the science education community from a methodological perspective. The authors conclude that further studies on the contents of physics textbooks should be conducted to address important challenging issues, or researchers' different views. More studies could be done on the conceptual and epistemic transitions of physics between educational levels to explore what should be taught at primary, secondary and tertiary levels. Also, collaboration among physics, educational, and linguistic disciplines could examine physics contents from different perspectives. Furthermore, more comparisons could be made to identify the distinctive features of physics content, in contrast to general science or other natural science disciplines such as chemistry or biology. The third presentation discusses the users' expectations about physics textbooks. The authors summarise content-related, form-related, and action-related expectations in inductive categories. Qualitative content analysis was undertaken for 39 papers, and 23 categories of expectations were defined. The authors conclude that most of these expectations have been stated by educational researchers, without any empirical investigation. Textbook authors' and publishers' expectations are unknown. Moreover, curriculum makers, students, and teachers are rarely asked about their expectations. The authors suggest that future systematic studies regarding the expectations of physics textbooks should be undertaken. The fourth presentation provides the results of the literature review of physics textbook evaluation. The authors discuss the evolution of PTEL (Physics Textbooks Evaluation Literature), and the milestones in its history. The analyses of 126 reviewed papers is based on three domains: content, pedagogy and presentation. In addition, the use of textbooks in their different formats (printed/electronic) is discussed. The authors conclude that, while PTEL serves a useful purpose in stimulating further research into physics textbook evaluation, the results of PTEL have insufficient influence on the development of physics textbooks. The four sections of the chapter (discussed in each presentation) highlight some interesting specific results, but also uncover several commonalities regarding time frames, significance of results and in conclusions. The number of papers published in physics textbook research has increased significantly over the past decade, but more systematic and continuing research and professional discussions are needed. This may lead to improvements in the development of physics textbooks, physics education and physics education research in general.

242 Evaluation of Physics Textbooks

Marika Kapanadze[1], Gabriela Jonas-Ahrend[2], Alexander Mazzolini[3], Fadeel Joubran[4]

[1]Ilia State University, Tbilisi, Georgia. [2]Paderborn University, Padeborn, Germany. [3]Swinburne University of Technology, Melbourne, Australia. [4]The Academic Arab College for Education, Haifa, Israel

Abstract

The presented paper provides a broad review of research publications that focus on the evaluation of physics textbooks. It provides a systematic analysis of the internationally-available, English-language literature published in different journals, books, reports, and conference

proceedings. The paper analyses and discusses physics textbook evaluation from different countries and different eras. The review discusses the aspects that influence the efficacy of physics textbooks, including the use of digital textbooks.

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243 Physics Textbooks and Curriculum Alignment: Focus and Conclusions of a Literature Review

Josip Slisko[1], Gabriela Jonas-Ahrend[2]

[1]Benemérita Universidad Autónoma de Puebla, Mexico, Mexico. [2]Paderborn University, Padeborn, Germany

Abstract

To define roles that textbooks play in physics teaching and learning, a four-level view of curriculum is useful: Intended Curriculum, Potentially Implemented Curriculum, Enacted Curriculum and Learned Curriculum. Physics textbooks are a crucial part of the Potentially Implemented Curriculum. The chapter related to physics textbooks and curriculum alignment, in the coming International Handbook of Physics Education, was a literature review focused on three types of articles, dealing with (a) analysis of the alignment of textbook contents and a particular national physics curriculum; (b) analysis alignment of textbook contents with a meta-curriculum framework and (c) analysis of some intra-curricular processes that are influenced by physics textbook features. In this presentation, the conclusions of that literature review are summarized and commented.

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245 Analysis of Physics Textbook Content

Xiaomei Yan[1], Yuze He[2]

[1]Shanghai Jiao Tong University, Shanghai, China. [2]Beijing Normal University, Beijing, China

Abstract

The content of physics textbooks has always been an important part of physics education research. This paper systematically reviewed the empirical studies on the contents of physics textbooks from the 1940s to 2021. There are 138 papers selected and categorized into the conceptual, epistemic, cultural levels of contents and the representations of contents in physics textbooks. The brief history and development of research was outlined, and representative research was identified. How different content analysis methods were also discussed from the methodology perspective. The findings show the researchers' continuous efforts on improving the validity of concepts and readability of texts, growing attentions on nature of science, argumentation and social equal issues, which is the similar to the development trend of science education research. Among the studies, the epistemic level of content attracts the most studies (with 49 papers), while the cultural level of content attracts the fewest papers (with 12 papers). The focus on the conceptual level of content enjoyed the longest history, which dated back to the 1940s. The implications for future research are provided, including the use of new

technologies and focus on multimedia texts

246 Expectations about Physics Textbooks: A Literature Review

Sascha Grusche[1], Alexander Strahl[2], Katrin Bölsterli Bardy[3]

[1]Technical University of Munich, Munich, Germany. [2]University of Salzburg, Salzburg, Austria. [3]University of Teacher Education Lucerne, Lucerne, Switzerland

Abstract

To gain an overview of expectations about physics textbooks, research papers about physics education are analyzed qualitatively. Content-related, form-related, and action-related expectations about physics textbooks are summarised in inductive categories. In the analyzed papers, most expectations have been stated normatively by education researchers. Thus, expectations by curriculum makers, authors, publishers, teachers, and students need to be studied more extensively in the future.

Parallel Session - 6.3 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

31 Tensions in The Primary Science Landscape and How Professional Learning Can Support Primary Teachers

Chair

Sarah Earle

Discussant

Deb McGregor

Abstract

Science in the primary and early years is increasingly regarded as important for supporting children's foundational concepts and enduring interest in science (e.g. Archer et al., 2020). Exactly how to guide pre-service and in-service primary teachers to support science learning continues to be debated internationally. This symposium brings together perspectives from Australia, Spain and England, to consider the primary science landscape in each cultural context and potential ways forward for supporting teacher practice. Paper 1 considers the landscape of primary science teacher education in Australia, including the push for 'classroom readiness' in initial teacher education. This exploratory qualitative study includes document analysis, together with teacher educator survey and interviews. Discussion includes consideration of the Australian policy landscape, the purpose of primary science and models of practice. Possibilities, challenges and future directions provide provocations to set the scene for wider

debate in the symposium. Paper 2 looks at how to support teaching and learning of science in the early primary school years. Early science is positioned as an engaging and creative discipline, leading to rich learning for all. The paper explores the principles behind the Sci-5 professional learning program, with lessons moving from a 'Provocation', to 'Practical tasks' and ending with time for children to 'Ponder'. Examples of kindergarten science inquiry will be provided, to support discussion of purposeful practical work in primary science. Paper 3 will take a broad look at the primary science education landscape in Spain, noting that many primary teachers do not study science content beyond the age of 14 due to the choice between experimental or social sciences at that stage. The study will consider teacher viewpoints in Navarre, including attitudes towards science, approaches to teaching science and use of informal science experiences. This study will directly feed into the creation of a new science museum's outreach offer and educational program, supporting children and teachers with primary science through informal learning contexts. Paper 4 considers the primary science landscape in England and notes the squeeze in both curriculum time and capacity for professional learning. The paper identifies that evidence of impact is needed to persuade schools to 'buy in' to in-service teacher training. The Teacher Assessment in Primary Science (TAPS) professional learning program, which has been the subject of a randomised control trial and national roll out, is examined to explore how such a program impacts practice in primary science teaching and formative use of assessment. Tensions regarding time for primary science teaching within a crowded curriculum and time for teacher professional development, together with the implications of the pandemic and ongoing teacher shortages, are recurring themes within the symposium. In addition, each locality has its own unique cultural context, that needs to be acknowledged and built upon, in the development of any possible solutions to the issues identified. The symposium will draw together findings from the three countries, together with consideration of perspectives from pre-service and in-service teacher educators, to explore global tensions and opportunities for the future.

268 Triumphs, Tensions and Future Directions in Australian Primary Science Teacher Education: A Landscape Analysis

Ange Fitzgerald[1], Kimberley Pressick-Kilborn[2], Reece Mills[3], Linda Pfeiffer[4], James Deehan[5]

[1]RMIT, Melbourne, Vic, Australia. [2]Newington College, Sydney, NSW, Australia. [3]QUT, Brisbane, Qld, Australia. [4]CQU, Gladstone, Qld, Australia. [5]CSU, Bathurst, NSW, Australia

Abstract

The spotlight on initial teacher education (ITE) in Australia continues to burn brightly (e.g., Ellis, 2022). This attention remains largely due to demands emerging from enduring national reform agendas around 'quality' and 'impact' (Bourke & Ryan, 2022; Brandenberg et al., 2016) as well as a teacher shortage crisis exacerbated by the global pandemic (McLean Davies & Watterson, 2022). Through these intersecting concerns, a narrative has emerged in ITE policy and practice calling for the 'classroom readiness' of graduate teachers (Green et al., 2018). Australia does not stand isolated in this policy-pandemic duality with similar tensions playing out on the

worldwide stage (see: LeTendre, 2021; Welch, 2022). What is largely unknown and unknowable now, however, is what happens next to create movement from airing to actioning these dual concerns of teacher quality and teacher shortages. This context provides an opportunity to turn our gaze to our respective field within ITE in the Australian context – primary science teacher education – and to surface practical and proactive ways forward in this 'messy' and complex space. While 'classroom-readiness' is a noble intention, the reality is that there is a lack of a holistic understanding of what is actually happening in terms of how these intentions may be achieved. This presentation explores the current purpose of and future possibilities for primary science teacher education, including models for practice, notions and implications of a science specialisation, and the inherent role of STEM education in building and enhancing science learning and teaching. While this subsequent introspection is largely positioned to inform understandings in an Australian setting, it is not at the expense of the international body of knowledge or what could be contributed to improving global practice. Specifically, this presentation seeks to provide a landscape analysis of the current 'state of play' of primary science teacher education.

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228 A Professional Learning Program to Support Practical Primary Science Teaching in the First Year of School in Australia

Christine Preston

University of Sydney, Sydney, Australia

Abstract

Every child deserves to experience high quality science learning throughout school. The cruciality of a scientifically literate citizen depends on quality, thought provoking school science. Initiatives aimed at increasing interest and fostering careers in science mostly target upper-primary or secondary years. Such efforts are 'too little, too late' because subject perceptions and career aspirations form during early primary school. Can science learning be invigorated from the get-go? A 'new' approach for thinking about and guiding the science learning of 5-year-olds commencing school is needed. In Australia, primary science struggles to maintain dedicated teaching time in a crowded curriculum. Though mandatory, primary science remains low priority, especially in the first year of school. Following recent government funding of a pre-school STEM initiative, it is time the focus shifted to the first year of school (Foundation Year in Australia). Primary teachers need support to ensure science is taught regularly and effectively in the first year of school. Science needs to be positioned as an engaging and creative discipline that children cannot do without. Such an aim is ambitious but achievable. Rich science learning for all children from the start of school is the vision of the Sci-5 professional learning program presented in this symposium paper. Sci-5 aims to provide inspiration for teachers to implement a high-quality science inquiry approach for 5-years-olds in the first year of primary school. This focussed, research-based intervention draws on my 20 years of experience as a teacher of kindergarten science. A multi-faceted program supported by teaching strategies and learning experiences that were designed and refined in the

classroom will involve teachers in developing their understanding of early years science and practical inquiry, together with authentic assessment. As an academic teacher-researcher I present a plan for targeted professional development towards enriched science learning from the start of school.

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475 Primary Science Education in Spain: A Landscape Survey of Teacher Confidence, School Leadership Support and CPD Opportunities for Teaching and Learning Primary Science

Marie Anne Reynell, Ruth Breeze, Martin Martinez, Maite Aznarez

University of Navarra, Navarra, Spain

Abstract

Science education in Spain is still struggling to catch up to the average European levels presented in the study Modernisation of higher education in Europe: funding and the social dimension. Although Spain has responded by creating a body (FECYT) to push for greater citizen science communication in an aim to promote science capital on a national level, little has been done to support teachers collectively and individually. The aim of the study is to collect data to inform the development of the Science Museum Biodiversity and Environmental Education Program (University of Navarra) which will commence in late 2023. The Education Program will offer local,regional, and national CPD and resources that will hope to impact teacher attitudes and confidence with respect to primary science teaching and learning, environmental education through inquiry based learning. The landscape survey will serve as an initial tool to map the scope of which aspects can be addressed successfully through teacher training programs, which aspects are better suited to inclusive Outreach programs and which aspects can be developed through community led actions.

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226 Consideration of the Impact of a Professional Learning Program to Support the Teaching and Assessment of Practical Primary Science in England

Sarah Earle

Bath Spa University, Bath, United Kingdom

Abstract

In England, primary science is fighting for time in an increasingly crowded curriculum and schools are requesting stronger evidence of impact to justify the time and money that could be spent on any professional learning program. This means that programs like the one described in this paper need to be clearer than ever about how teacher practice can change as a result of taking part in professional learning. The Teacher Assessment in Primary Science (TAPS) Focused Assessment approach proposes that one focus is selected within the context of a whole inquiry, to support teaching and assessment. A three-day Focus4TAPS professional learning program has been developed to support teachers to implement this approach in primary science. The course has been delivered face-to-face and online, and has been the

subject of a large-scale Education Endowment Foundation (EEF) randomized control trial in England. The EEF independent evaluation found a statistically significant impact on pupil learning. This paper will explore teacher survey data from the EEF evaluation, together with qualitative surveys completed by the course attendees during the program to consider the process of implementation of the training and described impact on practice. It is proposed that the TAPS Focused Assessment approach provides a manageable way for primary school teaching and assessment of science inquiry, but that a sustained professional development program is necessary to support teacher understanding of primary science and practical inquiry, together with formative use of assessment information gained from interaction with the children. This study provides insights that can inform the implementation of a similar approach in other contexts.

Parallel Session - 6.4 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

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25 Drawing Rich Pictures of Open Schooling and Its Implications for Sustainability and Science Education

Chair

Marta Romero-Ariza

Discussant

Peter Gray

Abstract

Many critical voices claim that very often, what is taught and learnt at school is far away from what people need to fully develop in life. The concept of scientific literacy refers to the set of values, skills and knowledge that citizens need to make informed decisions in situations related to science and technology in society, and to actively contribute to the debate of contemporary socio-scientific issues. To educate scientifically literate people, we need to better link science education to what is happening in the world, nowadays. Open schooling is a powerful approach to promote meaningful, transferable and relevant science learning, connected to the solution of authentic problems and the co-construction of a more sustainable world. Within the context of a European project funded by the European Union to support open schooling, this symposium intends to share the lessons learn while evaluating the implementation of open schooling through School Community Projects (SCP). SCP are projects that arise from students' needs and concerns about how to improve their school and neighbourhood. Learning takes place while students get engaged in the investigation of problems related to waste and energy and the co-construction of sustainability solutions, together with different experts and members of the community. Some of the outcomes of the project are: 1) a manual about how to support schools to become active agents of community well-being, fostering out-school collaboration

and co-creation and 2) a set of pedagogical guidelines for teachers about how to integrate SCP within their daily practice. In the context of this project, the present symposium will address the challenge of evaluating open schooling effects on students' interest in science, the perception of relevance of what they learn and their readiness to act as well-informed and highly committed citizens. This will be evaluated by searching for indicators of students' scientific literacy and sustainability consciousness before and after their participation in SCP. In addition, we will present several case studies to illustrate how open schooling has been operationalised in different cultural settings through the development of SCP. To this end, four contributions will be presented and discussed. The first one will introduce the context and the challenges related to evaluating the impact of open schooling through the implementation of SCP across 10 different European countries. In addition to describing the development and validation of evaluation instruments for a pre and post international study of the impact of SCP on student, the first contribution will present a common framework for a cross-national qualitative study aimed at understanding the key issues for successful open schooling and effective science learning. The qualitative study will illustrate the wide variety of ways in which SCP can be designed and implemented in different contexts. Furthermore, it will allow us to capture representative and inspiring cases and to unveil in-depth views to understand how to best support open schooling for science and sustainability education. The rest of the contributions to the symposium will present case studies conducted in three different countries, participating in the European project supporting this work. The three cases vary not only in the socio-cultural context where they were located, but also in the educational level of the participating students, the duration of the SCP and the issues and topics under investigation. However, the three cases have been developed to respond to the following research questions: 1) What are the key features of good SCP and the main barriers for a successful implementation? 2) How are SCP perceived by participants and what evidence do we have of their impact on students' learning and students' understanding of sustainability issues and their role in solving them.

290 The Discourse of Co-Creation in Interaction for School Community Projects

Metin Sardag[1], Gokhan Kaya[2], Gultekin Cakmakci[3]

[1]Van Yuzuncu Yil University, Van, Turkey. [2]Kastamonu University, Kastamonu, Turkey. [3]Hacettepe University, Ankara, Turkey

Abstract

This study aims to reveal the structure of student, teacher, and stakeholder interactions during the co-creation phase in the school community projects carried out within open schooling understanding. In this context, the researchers focused on three research questions: (1) Which communication approaches are used in the co-creation phase of school community projects? (2) What are students' contributions in the co-creation phase of school community projects? and (3) What are the interactional activities carried out to involve students in the co-creation phase of school community projects? The study was conducted using discourse analysis, which has a qualitative nature. The data come from meetings in the co-create phase of 12 school

community projects. These meetings took place online and were video recorded. The study's preliminary findings show that the session moderator predominantly used an interactive authoritative communication approach in the interactions in the co-create phase. When the students' contributions are analyzed, it is seen that they generally ask knowledge questions about the phenomenon underlying the school community project. These questions provide opportunities for stakeholders to present content related to their areas of expertise or social perspective in the process. Asking information and clarification questions to the students was mainly used to involve the students in the process. The study contributes to the science education literature by shedding light on the co-creation activities of students, teachers, and stakeholders from a discourse perspective.

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756 Developing a Framework to Evaluate Open Schooling for Science and Sustainability Education

Marta Romero-Ariza[1], Antonio Quesada[1], Ana M. Abril[1], María Martín-Peciña[1], Pilar López-García-Gallo[2]

[1]University of Jaén, Jaén, Spain, Spain. [2]Museo Nacional de Ciencias Naturales (MNCN-CSIC), Madrid, Spain, Spain

Abstract

The coronavirus pandemic demonstrates the importance of having highly qualified scientists but also the necessity to have scientifically literate people that can understand the implications of scientific advances and make informed decisions. Open Schooling (OS) has been envisioned as a powerful approach to foster relevant and meaningful science learning and to increase society's engagement in science and education. Within the context of a European project to improve science education through OS, this work describes the development of a questionnaire to evaluate the effects of OS on students' interest, scientific literacy and understanding of current environmental problems and their role in solving them. In addition, a framework for the development of case study will provide rich qualitative data allowing the identification of key factors and hindering circumstances, while providing a better understanding of how to enhance science and sustainability education through OS.

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878 Favoring School and Community Synergies for Addressing Sustainability Issues in the Town

Ana M. Abril[1], María Martín[1], Marta Romero-Ariza[1], Antonio Quesada[1], Pilar López García-Gallo[2]

[1]University of Jaén, Jaén, Spain, Spain. [2]Museo Nacional de Ciencias Naturales, Madrid, Spain, Spain

Abstract

On Monday, the school opens its doors and students and families find that everything is full of rubbish; curiosity assaults the walls of the center. This is the beginning of a school community project (SCP) carried out in a small town in XX following the open schooling features. The

context, which initially only affected the school, spread throughout the city. The design of the SCP by teachers, supported within a professional development course, as well as the involvement of students and the community, allowed open schooling. Within the context of a European project, a collection of case studies has been developed in order to illustrate good practices and understand how to improve STEM education through open schooling. This paper presents the analysis of one case to unveil the perceptions of the participants, the impact on students' learning, their role in solving problems, as well as key features of good SCP and the main barriers for a successful implementation.

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970 Open Schooling for Science and Sustainability Education - Case Studies From Norway

Maria Immaculata Maya Febri[1], Øistein Villa Rikheim[2], Hanne Valde Thu[3], Ragnhild Lyngved Staberg[1]

[1]Norwegian University Of Science And Technology, Trondheim, Norway. [2]Stasjonsfjellet lower secondary school, Oslo, Norway. [3]Akademiet lower secondary school, Lier, Norway

Abstract

Open schooling is a way to answer the call in the European science education policy to expand opportunities for science learning, in formal, non-formal and informal settings. Within our European open schooling project, students work with sustainability questions taken from authentic, realistic problems faced in real life (waste and energy). Students not only apply, analyze and evaluate their existing scientific knowledge, they also are encouraged and engaged to create new knowledge in terms of the solutions proposed in cooperation with local community members. In this paper we discuss key features of good open schooling projects, main barriers for successful implementation, participants perceptions and evidence for impact on students' learning and sustainability consciousness, based on two examples of Norwegian case studies. From our findings, we recommend that open schooling projects should stem from authentic problems for students, the students need to see the benefit of solving them making the project meaningful, the project should be closely related to the curriculum goals, teachers and students should feel the ownership to the project, and teachers/school leader and external actors (community members) should communicate closely.

Parallel Session - 6.5 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

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29 Promising Scholars of SIG6 Languages & Literacies in Science Education: New Research on Multimodality

Chair

Kok-Sing Tang

Discussant

Russell Tytler

Abstract

The ESERA SIG6 Languages and Literacies in Science Education was founded in 2018 with the aim of forming a research community interested in exploring how the languages of science, and their associated literacies, afford, mediate, support or hinder science teaching and learning. Over the past 5 years, the SIG has grown to a community of 117 registered ESERA members, and many more including affiliated members. An exciting part of this growth is the active participation of many early career researchers (ECR) who have joined the SIG in recent years. It is thus timely now for this invited symposium to showcase the promising work of several ECRs in the SIG. Through an open invitation to all the ECRs in SIG6, we received 15 outstanding proposals from 11 different countries. Five reviewers (Kok-Sing Tang, Russell Tytler, Sonya Martin, Eduardo Mortimer, Kristina Danielsson) then reviewed all the proposals and selected four best papers to be presented in this symposium. Collectively, the four papers in this symposium represent broadly the current "state of the art" research focusing on languages in science education. More specifically, the papers also share a common interest in multimodality – the notion that meaning is never made with a single mode (e.g., verbal language) but always through a combination of multiple modes, including speech, written texts, drawings, gestures, mathematical symbols, and material objects. This symposium thus aptly illustrates what we mean by "languages" in the SIG is not confined to a natural language like English, Norwegian, Korean or Luxembourgish, but they include also a range of multimodal representations and resources that are available for science meaning-making. Researchers in science education have generally acknowledged the importance of multimodality in the last two decades. Building on this ongoing research, the ECRs in this symposium apply and expand on the research on multimodality in the following novel areas and contexts. The first paper by Magdalena Kersting and Priscila Kohler connects multimodality to the research on metaphors, which has traditionally focused on their verbal manifestations. Integrating theoretical perspectives from embodied cognition, enactivism and social semiotics, they analyzed five Norwegian teachers' classroom discourse and provide novel accounts and analytical descriptions of metaphors that acknowledge their embodied, enactive and multimodal characteristics. The second paper by Mari Sjøberg and Erik Knain shifts the research on multimodality (often in classroom contexts) to a naturalistic laboratory setting in Norway where the genre of experiment is more dominant

than explanation in the classroom. Using social semiotics and interaction analysis, they investigated the interdependent relationship between multimodal representations and scientific genres and show how this relationship can both limit and afford students' representation construction. The third paper by Jina Chang and Joonhyeong Park applied a multimodal lens to the analysis of Virtual reality (VR) and augmented reality (AR) simulations that were designed to support inquiry activities in Korean elementary digital science textbooks. As VR and AR represent phenomena in new ways that are not possible in conventional media, their investigation of the multimodal affordances in VR/AR provides new insights on the use of multimodal representations that are mediated by emerging digital technologies. The fourth paper by Sara Wilmes and Chris Siry expands multimodal interaction analysis (MIA) to incorporate an analysis of space and place occurring in a plurilingual early-childhood classroom in Luxembourg. Using MIA coupled with geosemiotic analysis, they aim to show how space is not simply a container for interactions to take place, but rather it shapes the interactions as such. Their approach contributes to an expanded notion of science literacy in ways that are multilingual, multimodal, embodied, and situated in space and time.

229 Figures of Thought, Figures of Action: Science Teachers' Multimodal Use of Metaphors in their Instructional Practices

Magdalena Kersting[1], Priscila Kohler[2,3]

[1]University of Copenhagen, Copenhagen, Denmark. [2]University of Oslo, Oslo, Norway. [3]Eikeli High School, Hosle, Norway

Abstract

Science education research has a long tradition of examining the role of metaphors in teaching and learning science. However, much of the existing research has focused on verbal manifestations of metaphors, thereby failing to acknowledge aspects of metaphors that may occur in non-verbal representations. This study integrates perspectives from embodied cognition, enactivism, and the social semiotic theory of multimodality to explore how five science teachers used metaphors in speech, gesture, and other embodied modes in their instructional practices. Our findings show that the teachers employed metaphors primarily when introducing new concepts and almost exclusively when these concepts were abstract. While all observed metaphoric expressions had embodied sources, many metaphors were realised in more than one modality. The teachers often drew on non-verbal modalities such as gestures, drawings or material objects to cue the source domains, thereby enacting the metaphors. We conclude that the metaphorical performance of teachers is a dynamic process that is both embodied and enacted: a greater awareness of the dual function of metaphors as figures of thought and figures of action can help teachers better put metaphors to work.

387 Exploring the Interdependent Relationship Between Representation Construction and Genre in a Naturalistic Laboratory Setting

Mari Sjøberg[1], Erik Knain[2]

[1]University of SouthEaster-Norway, Borre, Norway. [2]University of Oslo, Oslo, Norway

Abstract

Research has illustrated the important role of different representations in supporting the development of students' scientific explanations. However, there is a lack of research focusing on the interdependent relationship between representations and different genres. In this comparative case-study study, we focus on investigating the relationship between different student-generated representations and genres in a naturalistic laboratory setting. By combining interaction analysis of video-data from two different student pairs with multimodal analysis of their texts and drawings, we illustrate the co-development of representations and genres over time. In the laboratory, students were asked to make drawings to explain observed phenomena and the two comparative pairs are chosen because they solved this task according to different genres. One student group made a large drawing showing a temporal sequence of events at both micro- and macro-level (explanation genre). The other pair of students seemed to frame the task according to the experiment genre. We show how students' initial task framing in different genres seems to both limit and afford their representation construction. For instance, the affordances of the drawing mode supported the development of a causal explanation in one of the pairs. The student group that wrote a typical experiment account, developed small drawings that mainly served an illustrative function focusing on the macro-level. We argue that the experiment genre limited the development of a mechanistic explanation for this pair in this setting.

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233 Multimodal Representation Patterns and their Pedagogical Roles in VR/AR Simulations: Focusing on Cases from Digital Science Textbooks in Korea

Jina Chang, Joonhyeong Park

Nanyang Technological University, Singapore, Singapore

Abstract

Virtual reality (VR) and augmented reality (AR) simulations show phenomena with the representations digitalised in multimodal ways, and the affordances of each mode of these multimodal representations can play critical roles in facilitating student science learning. This study aimed to investigate the multimodal representation patterns and their pedagogical roles provided in each stage of various simulations. The analysis was carried out focusing on 82 VR/AR simulations developed to support inquiry activities in elementary digital science textbooks in Korea. The results show a number of interesting patterns in terms of how different sets of multimodal representations tend to appear at each inquiry stage and what their pedagogical roles are in guiding inquiry activities. In the introduction stage, the verbal-text mode was used to introduce the inquiry focus and methods while the visual-auditory mode was

used at the same time to portray inquiry contexts and specific objects at different proportional scales. In the inquiry stage, the visual-gestural mode was used for affording observation of phenomena from various angles by rotating or moving a screen or selections of variables by touching it. The mathematical-symbolic mode provided a quantitative scale to prompt inferences about the relationships among variables. In the closing stage, the verbal-text mode or verbal-visual mode tended to be used to remind students of the inquiry focus and broaden it into related knowledge. Finally, educational implications are discussed in terms of how to use multimodal representations for developing VR/AR simulations and for supporting student inquiry activities in VR/AR.

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349 Mapping Multimodal Interaction in Classroom Spaces: Views Enabled Through the Geosemiotic

Sara Wilmes, Christina Siry

University of Luxembourg, Esch-sur-Alzette, na, Luxembourg

Abstract

Multimodal interaction analysis has provided insight into the diverse ways plurilingual students engage in science practices and meaning-making. In this presentation, we share a novel approach to exploring the embodied, material ways students interact in and through science by incorporating an element often missing in current science education analytical approaches, views of space and place. Through an analytical approach grounded in multimodal interaction analysis, coupled with geosemiotic analysis of space and place, we explore the structures that allow for student engagement in science practices, grounded in situated views of the multimodal ensembles formed through interactions in space and time. Contextualized views on how semiotic resource are mobilized by whom, when, and subsequent tracings of how semiotic ensembles travel (or not) among spaces of science engagement will be shared. We will show how diverse ensembles of semiotic resources were mobilized by students and teachers through open-ended science explorations of living organisms in an early-childhood multilingual classroom, in ways that were anchored in space and time. With this work we step towards expanded notions of science literacy in ways that are multimodal, embodied, and situated in space and time. Implications for primary science teaching will be shared, along with a pointed discussion of how integrating geosemiotic explorations of space adds insights into critical questions of semiotic resource availability, uptake, and mobilization during science meaning-making.

Parallel Session - 6.6 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

34 S|E|H Issues as Origin for Transfer in Research and Practice

Chair

Julia Arnold

Discussant

Kerstin Kremer

Abstract

Transfer is a broadly discussed goal of dissemination between the fields of scientific knowledge bases as well as societal, cultural or practical application areas. For education it means to ensure that knowledge generated through educational or (inter-)disciplinary research studies is put into a relevant context and can serve societal and practical needs. There are several ways that such knowledge can be transferred: e.g. professional development for educators and practitioners to bring findings into schools; sharing research findings with policymakers and decision-makers to inform the development of education policies and practices; incorporating new research findings into the curriculum; partnering with organizations in industry and the community to co-create solutions that address real-world problems; communicating research findings to the general public through various mediums such as social media, media, or public speaking or making research data, methods, and results available to other researchers and practitioners to encourage replication, validation and application of the findings in open science. Furthermore, contemporary conceptions address transfer through a bi- and multi-directional communication process, that relates scientific knowledge to practical and societal implications and vice versa and implies co-creation and participation. Transfer can happen or be done between different groups, e.g. age groups, professional groups, cultural groups, social groups etc. Science|Environment|Health (S|E|H) pedagogy is searching for a mutual benefit between science education, as well as environmental, sustainability and health education and from this perspective incorporates the concept of transfer within its approach. This invited symposium of ESERA SIG 4 Science|Environment|Health focuses on existing research approaches from the S|E|H community and discusses these in the light of transfer implications between research and application areas. The symposium starts with a co-designed research study on beliefs about the use of (alternative) medical treatments between China and Germany. The authors thereby address transfer as transfer between cultures will discuss biology and prospective teacher students' beliefs in the light of cultural influences towards teaching practices. The second contribution examines the role of prospective teacher students' self-efficacy beliefs as a prerequisite for transfer of S|E|H objectives between teacher education and classroom practice in Austria as part of the ERASMUS+ project "Teaching standard STEM topics with a key competence approach" (STEMKey). Here, transfer can be seen as transfer between professional groups. The next contribution originates from the Spanish context and addresses

the current global crisis and requirements of innovative strategies to improve teachers', students', their families', and communities' competencies via Children to Parent Intergenerational Learning (CPIL). This clearly addresses transfer as transfer between generations. The last contribution deals with a research approach towards teachers' conceptions on the nature of science education itself following the FRA approach. The contribution will discuss the results in the context of transfer processes between teaching practice and educational research in science as well as for the specific requirements of NOS understanding within S|E|H contexts and thereby addresses transfer as transfer between theory and practice. The symposium has the objective to exchange ideas and perspectives for transfer processes as well as desireable research necessities and its implications for S|E|H pedagogy and wants to gather ideas as well as participants for a new book publication project of the SIG about S|E|H transfer processes between research and practice communities.

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270 First-Year Biology Students' Beliefs about Alternative Medicine and Evidence-based Medicine – an International Comparative Study between China and Germany

Elvira Schmidt[1], Kerstin Kremer[1], Jing Jin[2], Shu-Nu Cang Rundgren[2]

[1]Justus-Liebig-University Giessen, Gießen, Germany. [2]Stockholm University, Stockholm, Sweden

Abstract

The interplay of Science and Health Education is international a central goal of Science|Environment|Health (S|E|H) pedagogy (Zeyer, 2012). Up to now, the content of Evidence-based Medicine and Alternative Medicine (also called Paramedicine) have only played a marginal role in German biology classes (Schmidt, 2020) and they are not included in the Chinese curriculum for the subject of biology, although the use of Alternative Medicine and the role for society is widespread in both countries. However, research reports differences in the popularity of individual Alternative Medicine treatments between Chinese and German students (Hamdorf, 2018; Xie et al., 2020). These differences emphasize the need of investigating the variables that influence the intention to use Alternative Medicine and Evidence-based Medicine for understanding cultural differences towards health literacy in a holistic way. Accordingly, the study aims to explore Chinese and German first-year biology students' beliefs of using the two kinds of medical treatments. Based on the Theory of Planned Behavior (Fishbein and Ajzen, 2010), the study measures behavioral, normative and control beliefs to use Alternative Medicine and Evidence-based Medicine. The results reveal the use of Alternative Medicine and Evidence-based Medicine in cultural contexts and further contribute to health literacy and science-based health education in Alternative Medicine and Evidence-based Medicine (Schmidt, 2020). Some selected results analyzed via content analysis based on an open-ended questionnaire will be presented and discussed in the symposium.

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271 On the Transfer of SIEIH Objectives from Teacher Education to Classroom Practice: Results of a qualitative Study on the Self-Efficacy of prospective Biology Teachers

Dunja Peduzzi, Suzanne Kapelari

University of Innsbruck, Innsbruck, Austria

Abstract

This symposium contribution presents results of a qualitative study on the carbon cycle and the carbon cycle teaching self-efficacy of prospective biology teachers during and after a subject-didactic course on this topic at our University. Positive self-efficacy perceptions and the development of positive self-efficacy beliefs (Bandura, 1977) in the field of SciencelEnvironmentlHealth during teacher education are prerequisites for prospective biology teachers to actually integrate objectives of the ScienceïEnvironmentïHealth pedagogy into their future teaching practice (Malandrakis, Papadopoulou, Gavrilakis, & Mogias, 2019). Self-efficacy was assessed by: i) qualitative nonparticipant observations in person of nonverbal and verbal behaviours during the course (Bottorf, 2004) and ii) individual qualitative semi-structured interviews (Mason, 2004) with the students five weeks after the end of the course. Qualitative content analyses were conducted to analyse the data. Preliminary results illustrate the significance of self-efficacy for the successful transfer of SciencelEnvironmentlHealth objectives from teacher education to practice.

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273 S|E|H Transfer in the Spanish Context. A longitudinal Study of intergenerational learning of the Climate Change Competence (C3) - Introducing EDUC3

Olga Mayoral[1], Camilo Ruiz[2], José-Reyes Ruiz-Gallardo[3]

[1]Universitat de València, València, Spain. [2]University of Salamanca, Salamanca, Spain. [3]University of Castilla-La Mancha, Ciudad Real, Spain

Abstract

Addressing the current global crisis requires a complex and specific educational approach, especially when coping with Climate Change issues. In this sense, the Climate Change Competence (C3) is a fundamental cornerstone for which a Science|Environment|Health [S|E|H] perspective could be particularly beneficial. The research project that we present here focuses on the design, implementation, and assessment of innovative educational strategies to improve this competence in teachers, students, their families, and communities around schools of several regions in Spain. The project's main goal is to perform a longitudinal experiment to assess the efficiency of educational interventions designed to build a chain reaction between the triad teachers-students-families via Children to Parent Intergenerational Learning (CPIL). Preliminary results of this study will be presented at the conference.

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272 A Family Resemblance Appraoch to Science Education Research: Biology Teachers' Conceptions on Transfer

Alexander Büssing

Leibniz University Hanover, Hanover, Germany

Abstract

Transfer remains a central problem specifically to issues of Science|Environment|Health (S|E|H), as research and school practice may depend on different cultures with different aims and values, contradicting approaches of curricular and pedagogical innovation such as S|E|H. While prior approaches often focused on cognitive dimensions such as methods and knowledge, the present paper proposes the further investigation of social-institutional characteristics of science education as one requirement to better understand the affordances of school practice for guiding transfer. Using a semi-structured interview guide informed by the Family Resemblance Approach (FRA) from nature of science we interviewed 11 in-service biology teachers specifically about how they understand the category most relevant for transfer of S|E|H-issues into schools (social certification and dissemination). Using a stepwise grounded theory approach, several inductive categories showed possibilities of how biology teachers believe a better dissemination of results could be achieved. Furthermore, they reported about occurrences, how results from biology education are certified in school practice. Even if only few teachers reported to discuss biology education results with their colleagues, they also mentioned several critical perspectives, important for guiding future research transfer. Besides these qualitative results, we investigated connections between categories. Overall, codings of social certification and dissemination most often co-occurred with social organizations and interactions but also social values. Based on these results, challenges based on the social organization of science education but also the different values from research and school practice impede teachers from perceiving new science educational research results and adapting them to practice. In conclusion, cultural differences may undermine the integration of the of S|E|H-issues into schools, as the required changes in pedagogy may not be possible using traditional understandings of both research and school practice.

Parallel Session - 6.7 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

35 Emotions and Identity in Science Education Research

Chair

Allison Gonsalves

Discussant

Katie Wade-Jaimes

Abstract

Science education researchers are only beginning to investigate the role of emotions in the self-making and becoming of science identities. In her 2020 article, Lucy Avraamidou compels us to investigate how emotions and intersectionality can be more comprehensively integrated into our research frameworks, to give a more complex and nuanced picture of how identities are done in science. We regard the intersection of emotions and identities in science learning as central to our work and in this symposium, we feature four early career researchers who take different perspectives on understanding emotions in science identity work. By centering emotions, we take the position that emotions are not personal or individually experienced but are rather produced in relations and contexts. This raises important identity questions about the institutionally accepted norms or expectations for emotions in learning contexts. Boler (1999) argues that we are taught that some emotions are appropriate in certain contexts, and others should be repressed. The emotions of some are belittled, and the emotions of others are taken as normal or exemplary. What is acceptable in science learning contexts may be aligned with the kinds of identities that are valued in those contexts. Avraamidou (2020) argues "science identity is emotional given that it involves processes of becoming which are associated with visions of self, goals, aspirations, beliefs, and enculturation in specific social, historical, and geopolitical contexts" (p. 337). However, emotions are also bound within power structures as part of a web of relations between who is expressing feelings, who is receiving them, and the social hierarchies therein. Thus, learning in science contexts means successfully navigating emotions in a network of racialized and gendered relations, as one negotiates the landscape of becoming in science. In this symposium we feature presentations representing four different perspectives on research investigating emotions and identity in science education. Katerina Pia Günter and Maria Wallace prelude this symposium with a reflexive discussion on our own practices in science identity research. Critically thinking with and through the stories we choose to tell stories with, as inspired by Donna Haraway (2016), they reflect on temporalities of the currently emerging affective turn in science identity research, asking: What stories have we been telling? How come emotions have not been part of these stories? Amal Ibourk present research drawing on Hufnagel (2017)'s framework that attends to emotional expressions about climate change as it pertains to learning and teaching. In her presentation, she focuses on using the two features of aboutness and type of emotion. Ibourk use these features as lenses to see

how they surfaced in the climate stories of two in-service elementary teachers and how it informed their climate change identity as they co-developed a climate change justice curriculum and engaged with deeper learning of climate change and climate change teaching. Francesco DeZuani and Olivia Levrini will discuss the concept of "epistemic identity", meant as a special relationship between physics epistemology and students' identity construction. They will discuss an example of educational reconstruction and classroom implementation, which promotes the epistemology of physics of complexity as a scaffolding for identity development. Finally, Alison Mercier and Heidi Carlone will discuss a process of identity development called identity play – a more agentic, nonlinear, and not necessarily predictable form of identity development. They will discuss how this construct emerged from a longitudinal student of youths' identities in a multi-year, out-of-school science program and the role of vitality, embodiment, and emotion in prompting identity play. The discussant will identify commonalities and departures among these presentations, and will present a view for future research on emotions and identity in science education.

565 A Story Under Erasure: Complicating 'The Promise' of the Affective Turn Within Science Identity Research Through Feminist Reflexivity

Katerina Pia Günter[1,2], Maria F.G. Wallace[3]

[1]Uppsala University, Uppsala, Sweden. [2]San Francisco State University, San Francisco, CA, USA. [3]University of Southern Mississippi, Hattiesburg, MS, USA

Abstract

Using feminist reflexivity and a plurality of onto-epistemological perspectives, hegemonic traditions shaping educational research, critical questions for thinking about 'the affective turn' in science identity research are rendered visible. Critically thinking with and through the complex entanglement of story(ing) the studying emotions in research on science identity, provocations for the field are illuminated: What stories have we been telling about emotions in science? What stories contribute to the erasure of emotion for cultivating a complex understanding of science identity? Inspired by feminist theorists from transdisciplinary contexts, this work grapples with the temporalities of the emerging affective turn in science identity research.

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315 Using Storied-Identity and Emotional Sensemaking Lenses to Inform Elementary Teachers' Climate Change Identity Development

Amal Ibourk

Florida State University, Tallahassee, FL, USA

Abstract

Drawing on Hufnagel (2017)'s framework that attends to emotional expressions about climate change as it pertains to learning and teaching, I focus on using the two features of aboutness

and type of emotion. I use them as lenses to see how they surfaced in the climate stories of two in-service elementary teachers and how it informed their climate change identity as they co-developed a climate change justice curriculum and engaged with deeper learning of climate change and climate change teaching. I posit that emotional sensemaking of climate change cannot be understood without the contexts it is connected to- namely the emotions and the stories one ties them to. My argument also in this paper is that a storied-identity methodology can contribute to the emerging research in the emotional sensemaking of climate change. In what follows, I will provide how I approached the study theoretically and methodologically and the data analysis. Findings about how we reasoned about climate change emotionally as we experienced the effects of hurricane Ian are shared.

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329 Educational Reconstruction to Promote Physics Epistemic Identity

Francesco De Zuani Cassina, Olivia Levrini

University of Bologna, Bologna, Italy

Abstract

In this contribution, we discuss the concept of "epistemic identity", meant as a special relationship between physics epistemology and students' identity construction. Many studies within the science education community aim to find the conditions that make science education settings inclusive and safe, where students are encouraged and supported to nurture their identity development. Less attention is paid to the impact of the content and its epistemological nature on identity formation. Indeed, we claim that, as well as the context reconstruction, also the content and its epistemology should be reconstructed, by making it a productive source (or driver) for identity construction. In the first part of the talk we briefly present the state of the art about science identity. In the second part, we describe our approach to epistemic physics identity and epistemic emotions, by stressing the potentialities of the Model of Educational Reconstruction (MER) in triggering them. Finally, in the last part we discuss an example of educational reconstruction of the physics of complex systems that is at the basis of a classroom implementation.

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292 Self-Making Through Identity Play and Vitality in Environmental Learning

Alison Mercier[1], Heidi Carlone[2]

[1]University of Wyoming, Laramie, WY, USA. [2]Vanderbilt University, Nashville, TN, USA

Abstract

This presentation illustrates a process of identity development, called identity play, which is more agentic, nonlinear, and not necessarily cumulative or predictable that the ways identity development and identity work have previously been considered. This construct emerged from a longitudinal study of youths' identities in a multi-year, out-of-school program for middle school youth focused on environmental problem solving. Exploration of identity play

highlighted its entanglements with embodiment, emotion, and an energy and dynamism. We outline and describe the construct of identity play and explain vitality's role in prompting it.

Parallel Session - 6.8 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

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36 Out-of-Field Science Teaching: Supporting the Crossing of Disciplinary Boundaries

Chair

David Perl-Nussbaum, Kyla Smith

Discussant

Linda Hobbs

Abstract

Out-of-field (OOF) teaching is a global educational challenge, highly prevalent in secondary school mathematics and science. The negative impact of OOF teaching on student learning and teacher well-being is consistently emphasized, yet solutions to the problem remain limited due to systemic issues of teacher supply and the complexity of the phenomenon. However, OOF teaching is not a lost cause: much can be done to help these teachers cross the boundaries into their new teaching field. Educational researchers have begun to explore and document effective features for professional development, retraining, or upskilling of OOF teachers, pointing to the need to tailor these programs to the unique experiences of OOF teachers and to provide them with ongoing and comprehensive support. The proposed symposium echoes this line of research and suggests that OOF teaching can also be seen as an opportunity. Understanding the specific experiences, challenges and backgrounds of OOF teachers can help to tailor productive opportunities for their development and increase their self-efficacy, leading to identity expansion and feelings of accomplishment and even enjoyment. Participants in this symposium share the premise that the challenge of OOF teaching is context-dependent: the nature of the OOF teaching experience, challenges, and successes are rooted in the nature of the discipline the teachers enter as well as the discipline from which they come. The four following contributions focus on *OOF science teaching*. Using the *boundary-crossing* framework, we will attempt to describe the specific boundaries that OOF science teachers face and explore the implications for teacher learning and professional development programs that aim to facilitate their boundary-crossing into the science teaching culture. The first contribution describes the development of a framework to explore how discipline shapes the subject-specific demands on OOF teachers. In particular, it addresses how the ways of knowing, doing, and being as a science teacher differs from other disciplines and the discontinuities these differences place on OOF teachers. The second contribution reports

findings from western Canada and focuses on science teachers' self-efficacy and how it relates to how far out-of-field they feel and their primary disciplinary background. The third and fourth contributions take these insights and translate them into design features for teacher educators working with OOF science teachers. The third contribution reports on the design of a large-scale re-credentialing program in Victoria, Australia, tailored to the specific needs of OOF science teachers and successively refined to adjust to teacher needs. The fourth contribution describes a professional development approach for out-of-field physics teachers in Israel that builds on their prior disciplinary resources to facilitate their boundary crossing into inquiry-based physics teaching. The contributions raise mutual dilemmas, both theoretical and practical, which will be discussed at the symposium. For example, the role of interdisciplinarity in the research and development of OOF teachers versus the existing compartmentalization of school subjects, or the ways in which research in this area can inform large-scale educational policy. The proposed symposium will provide an opportunity for researchers to discuss the challenge of OOF science teaching from a variety of perspectives, combining findings from different countries and using different research methods, including interdisciplinary collaborative research, large-scale questionnaires, design-based research, and cross-case studies. In this way, the symposium will contribute to a better understanding of OOF teaching in the sciences, as well as research-based pathways to address this pressing issue.

301 A Framework to Inform Out-Of-Field Teacher Expertise in STEM Subjects

Seamus Delaney[1], Jared Carpendale[2], Linda Hobbs[3]

[1]Deakin University, Melbourne, Victoria, Australia. [2]Massey University, Palmerston North, New Zealand. [3]Deakin University, Geelong, Victoria, Australia

Abstract

Teaching is a learning profession but learning to teach out-of-field places subject-specific demands on teachers that can challenge teachers' knowledge, practice and identity. We use the notions of 'discipline' and Shulman's 'signature pedagogies' to interrogate what is distinctive about the subjects, and what out-of-field teachers need to know (thinking), do (performing) and be (acting and identity). As teacher educators/researchers from science, geography, English and mathematics education, we used a collaborative and interdisciplinary research methodology to invite dialogue between different disciplinary experts. Through collaboration and negotiation we generated a draft framework of subject specific expertise that invites dialogue on the relationships between disciplinary ideas of knowing, doing and being, and subject related teacher identity, inquiry (how knowledge is generated), knowledge (curriculum and content), connections (between disciplinary knowledge and between the individual and the world), and pedagogical imperatives (that drive teacher practice). These core salient elements sit within the broader context of education and the disciplines, which are contested and constantly changing, influenced by social, cultural and political forces. Such a framework has the potential to underpin conversations between subject-experts and out-of-field teachers to support crossing the boundary between familiar and unfamiliar fields of

knowing, doing and being. This presentation will introduce the framework and illustrate how the framework can be translated into science in comparison to some of the other subjects explored.

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317 "There are so Many Disciplines in Science!": Teaching Science Out-Of-Field and the Relationship with Teacher Self-Efficacy

Kyla Smith, Judith Hillier, Sibel Erduran

University of Oxford, Oxford, United Kingdom

Abstract

Out-of-field teaching, or the practice of teachers being assigned to teach classes beyond their specialized knowledge base, is a phenomenon that exists in education systems world-wide. Problems with out-of-field teaching range from higher rates of teacher burnout to negative impacts on student achievement. This presentation considers the case of out-of-field teaching in secondary school general science courses. It is found that due to the combination of topics from different scientific disciplines, even those with an educational background in one or more scientific disciplines may feel out-of-field when teaching general science courses. Additionally, a significant negative correlation is found between teacher self-efficacy in science and the extent to which teachers feel out-of-field when teaching science.

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319 A System Approach to Re-Specialising Out-Of-Field Teachers of Science and Mathematics

Peta White, Russell Tytler, John Cripps Clark, Amanda Peters

Deakin University, Melbourne, Victoria, Australia

Abstract

Teaching secondary school science and mathematics by out-of-field teachers is of increasing concern in Australia and internationally. Governments have been looking to formulate a policy response to the issue, but this is difficult given teacher supply issues. This paper describes an approach to re-credentialling teachers at scale as a system-wide response involving the support of schools and teachers to undertake a part-time post-graduate qualification in science or in mathematics. These courses were designed to explicitly cater for projected teacher needs in content and pedagogy and to induct teachers into the subject cultures of the respective disciplines. We describe the nature of the courses and the motivations and experience of participant teachers. We draw on evidence from the design-based research underpinning the courses to describe the expectations of teachers, particularly from the science course. We explore the ways in which the science course structures and pedagogies were successively refined to adjust to teacher needs regarding teaching and learning within their communities including adjusting to the demands of returning to study and eliciting support within their own school cultures. We discuss the particular needs of out-of-field teachers and the implications of

the findings for professional growth of teachers across subject boundaries at the system level.

320 Out-Of-Field Physics Teachers Crossing the Boundaries of Inquiry

Edit Yerushalmi, David Perl-Nussbaum, Zehorit Kapach

Weizmann Institute of Science, Rehovot, Israel

Abstract

Out-of-field (OOF) teaching is a worldwide challenge, especially in middle school physics. A major challenge for OOF physics teachers is directing inquiry-based learning activities that are often included in middle school science curricula. The difficulty arises from the different ways in which scientific inquiry is represented in each discipline. In school physics, inquiry is typically conducted to test or verify a theoretical relation, whereas in school biology the emphasis is on the empirical aspects of inquiry. We report on a professional development program specifically designed to enable OOF physics teachers (usually with a background in biology) to build on their primary disciplinary resources in the context of physics teaching. Using the boundary-crossing framework, we identified three types of boundary-crossing mechanisms through which OOF teachers successfully conducted inquiry in their classrooms. We characterize the boundary objects that facilitated teachers' bridging between disciplines: either they investigated a biology-associated phenomenon using theoretical modeling tools or they investigated a physics-associated phenomenon using experimental practices and conceptual knowledge they imported from their biology learning and teaching experiences. These findings reinforce the conjecture that the prior knowledge and epistemic cognition of OOF teachers should be considered as productive resources for their professional development in their new field.

Parallel Session - 6.9 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

37 Addressing Integrated STEM Teacher Education from Different Perspectives

Chair

Sevgi Aydin Gunbatar, Gillian Roehrig

Discussant

Selcen Guzey

Abstract

The recent Integrated Science, Technology, Engineering, and Mathematics (STEM) education reform, which is on the agenda in many countries, aims to raise individuals who are interested

in STEM fields, can solve problems, and contribute to production. Many factors play an essential role in the success of this reform movement. Among them, teacher education is the key to success. Professional development programs (PD) that are long-term, providing the active participation of teachers and collaboration with STEM education experts have been emphasized by the literature. Regarding teacher education for integrated STEM reform, research also revealed that teachers have limited knowledge of engineering and have problems in engineering integration. Especially earth and life science teachers had difficulties integrating engineering into their science units. Moreover, the interdisciplinarity of STEM implementations in K-12 classrooms deserves attention. Additionally, design-based pedagogy has been highlighted, however, in the related literature; there have been different implementations of design-based practices. Hence, it is important to learn about previous design experiences in an international context. Knowing about how these activities were planned and executed will help curriculum designers, and teachers in planning design activities and supporting the design thinking of students. In this symposium, we will focus on the important points aforementioned. In the first presentation, researchers from The Netherlands and Turkey will present a systematic review of design-based learning practices in K-12 classrooms. This review study screened 669 articles and included 77 articles in the review. In the second one, researchers from the US and Turkey will present earth and life science teachers' engineering integration into science after participation in engineering-focused STEM PD. Analysis showed that the extent and timing of engineering integration and the extent of conceptual connections between science and engineering varied in the teachers' classrooms. Additionally, teachers had problems establishing a deep conceptual connection between the science concepts focused on and their use throughout the design process. The third paper will provide results on the impact of the STEAM-PD on Egyptian teachers' practices and professional growth. The participant teachers indicated changes in their practice from traditional teacher-led pedagogies to those that were student-centered and linked to real-life situations for meaningful learning. Finally, the last paper will offer valuable results for positioning Australian teachers as co-researchers investigating problem-based learning in school STEM education. Actively positioning teachers as co-researchers challenges the expected roles of academic researchers and teachers, and raises key issues influencing choices at all stages of research design and knowledge production. When such considerations are effectively addressed, teachers think and work differently, clearly articulating the deep thinking driving their teaching. To conclude, the symposium will address integrated STEM teacher education from different perspectives, which is essential for the future of the STEM approach, and will present the impact of long-term PDs given in different countries with different emphases on teachers' practices, identity, and professional growth.

312 To STEAM or Not to STEAM: Is it a Matter of Professional Development or Professional Creation?

Heba EL-Deghaidy, Mohamed El Nagdi

American University in Cairo, Cairo, Egypt

Abstract

A professional educator diploma (PED) programme for teachers' professional development (PD) is directed to existing teachers and professional creation (PC) directed to prospective teachers for both to work at STEM schools. The programme builds teachers' capacity to design, present and assess in interdisciplinary learning contexts through professional development and creation. A case study research design is utilized with data from post programme semi-structured interviews from continuing and graduating teachers. Findings offer insights on the impact the PED programme on teachers' practices and how to improve PD programmes in STEM/STEAM education for teachers.

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316 Design Process in K-12 Education: Preliminary Findings of a Systematic Review

Cui Ping[1], İbrahim Delen[2], Durdane Bayram-Jacobs[1]

[1]Eindhoven University of Technology, Eindhoven, Netherlands. [2]Usak University, Usak, Turkey

Abstract

There is a big emphasis on design based learning and the number of studies continue to grow steadily. In this process, it is important to understand how design based practices are implemented in K-12 classrooms. The preliminary findings of our systematic review are based on 77 publications that were published between 2018 and 2021 in the Web of Science, Scopus, ERIC, and APA PsyINFO databases. We discovered that the amount of time spent on design ranges from one class period to one semester, and each study had specific design process goals based on the content. The vast majority of the research in the publications in our sample was carried out in the United States, and science remained the most popular discipline. The popular participant group was secondary school (middle and high school) students. Only papers that involved students in the design process were included in our review; however, we could only disclose specifics on the design process in 32% of the articles.To achieve coherence among design-based applications, our first findings reveal many important discrepancies that should be carefully taken into account.

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372 Teachers as Co-Researchers Investigating Problem-Based Learning in School STEM Education

Amanda Berry[1], Kathy Smith[1], Jennifer Mansfield[2], Peter Ellerton[3]

[1]Monash University, Clayton, Victoria, Australia. [2]Monash, Clayton, Victoria, Australia. [3]University of Queensland, Brisbane, Queensland, Australia

Abstract

Teachers are key to fostering their students' future STEM interests and the development of students' STEM knowledge, skills and capabilities. To effectively fulfil their role, teachers need to acquire appropriate professional knowledge, as well as the capacity and confidence to

design and implement authentic and relevant STEM education. This study brings together Australian middle school teachers and university-based academics to: (i) co-generate a set of research-informed principles of practice for a Problem Based Learning (PBL) model of STEM Education and, (ii) embed these principles of practice into a coherent and sustainable pedagogical framework. Foundational to the study is the active positioning of teachers as co-researchers, drawing on their experience and expertise as they interrogate their practice to understand how key principles defining a PBL approach can be effectively translated into different school contexts. A design-based research approach was utilised, with data drawn over three years from varied data sets including online teacher surveys, university-based facilitator reflections, teacher action research plans, audio-taped teacher interviews and teacher-to-teacher discussions. Study outcomes include a set of emerging considerations which influence the research design and knowledge production process. Each consideration also raises insights into the challenges and opportunities that come from positioning teachers as co-researchers in PBL based STEM Education.

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454 Science and Engineering Integration: Earth and Life Science Teachers' STEM Implementations

Sevgi Aydin-Gunbatar[1], Nilay Ozturk[2], Gillian Roehrig[3]

[1]Van Yuzuncu Yil University, Van, Turkey. [2]Bahçeşehir University, İstanbul, Turkey. [3]University of Minnesota, St. Paul, Minnesota, USA

Abstract

This study aimed to investigate how elementary and middle school science teachers integrated engineering into their planned science instruction and the extent they conceptually linked science to engineering following participation in a professional development program. Video recordings of three teachers' classroom implementation of teacher-designed units were the main data sources, and the integrated STEM unit plans were used as a secondary source. Analysis showed that the extent and timing of engineering integration and the extent of conceptual connections between science and engineering varied in the three teachers' classrooms. Each of the teachers started the instruction with an engineering design challenge and gave students a chance to redesign their engineering solutions; however, only one teacher asked for design justifications, and none of the teachers could establish a deep conceptual connection. The findings of the study revealed a need for further teacher professional development and documented the difficulty of engineering integration in earth and life science content domains.

Parallel Session - 6.10 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

42 Physics Education Research and Computational Science: Determinants, Limitations, and Perspectives

Chairs

Sarantos Psycharis, Apostolos Xenakis, Konstantinos Kalovrektis,

Discussants

Michail Kalogiannakis, Stamatios Papadakis, Ioannis-Alkinoos Zourmpakis, Effransia Tzagaraki, Dimitris Psillos, Christos Xenakis

Abstract

Over the last two decades, discussions, rhetoric, recommendations have proposed numerous suggestions for the inclusion of new tools and methods -based on acquisition of real data using the methodology of Computational Science and the so called "Computational experiment"- in Physics and Science Education. New aspects like artificial intelligence, virtual and mixed reality etc can serve as PER practices in alignment with the 21st century skills. In this symposium certain approaches related to PER(Physics Education Research) are presented.

The article: STEM Based Astronomy Activities With Ancient Minoan Analogue Computer, presents an holistic approach- based in the area of Astronomy-for the use of an ancient analogue computer of Greece , as a navigation instrument for finding the latitude of a place and as a system for predicting eclipses of the Sun and Moon. This article can also serve as a triggering entrance to advance the so called STEM competencies through the engagement of students in acquisition of real data.

The article: The Role and Impact of Virtual Laboratories In Enriching and Transforming Laboratory Work In Physics Education, presents in a concise and compact form the use of virtual laboratories (VLs) in curricula and teaching practices, due to their powerful and increasing affordances. The purpose of this paper is to discuss empirical studies published mainly since 2010 concerning the integration of VLs in physics teaching and learning, outline findings and their implications, identify open issues and provide suggestions for further research. The impact of the use of VLs on students' conceptual learning, development of scientific skills, attitudes, and perceptions of their experiences is revealed and discussed.

The article: Technological Pedagogical Content Knowledge (TPACK) In Physics Education, presents an extensive literature, review for the " technological pedagogical content knowledge (TPACK) " and its relation physics education. By providing detailed information on what teachers/instructors need to know and what they can do to incorporate technology into their teaching experiences, it summarizes the main issues in the TPACK framework literature and

technology integration in teaching while it also presents the research that dealt with TPACK in physics education by indicating the gaps in the literature and implications for further research.

The article: Education of Elementary Teachers on the Use of Adaptive Gamification Environment in Science Education, investigates the training of teachers regarding the use of an adaptive gamification application in teaching science education concepts in elementary education. Specifically, in this study, teachers are trained based on Technological Pedagogical Science Knowledge (TPASK) model to utilize an adaptive gamification environment that follows a specific methodology concerning science education. Article also presents data that relate PER with psychological structures like self-efficacy, and motivation, essential for a pragmatic implementation of TPASK in the classroom.

The article: Development and Implementation of a Robotic Activity Through BBC Micro:Bit for Teaching Electricity to 5th Graders, examines whether teaching using educational robotics improves the academic performance of the students to a greater extent than the traditional teaching of electricity for students in the 5th grade. It also examines whether their attitudes towards physics are affected after having been taught using the Activity. To achieve this goal, a Teaching Learning Sequence (TLS) was designed and implemented. The results of the research, when it is completed, will contribute to research that focuses on designing educational programmes, focusing on the pedagogy of science and STEM courses, as well as the use of educational robotics in the classroom.

383 Education of Elementary Teachers on the Use of Adaptive Gamification Environment in Science Education

Ioannis-Alkinoos Zourmpakis, Stamatios Papadakis, Michail Kalogiannakis

University of Crete, Rethymnon, Greece

Abstract

This study investigates the training of teachers regarding the use of an adaptive gamification application in teaching science education concepts in elementary education. Specifically, in this study, teachers are trained based on Technological Pedagogical Science Knowledge (TPASK) model to utilize an adaptive gamification environment that follows a specific methodology concerning science education. Our point of interest was to collect data on the teachers' perceptions regarding their readiness, self-efficacy, and motivation to integrate this digital application into the classroom. The data were collected through questionnaires before and after the teachers' training held remotely from December 2022 to early January 2023. They indicate an above-average perception regarding their TPASK dimensions, the increase of mainly the TPASK-specific dimension, and the enhancement of their understanding of the adaptive gamification environment and its use in teaching. Furthermore, teachers showed an increase in their self-efficacy after the training and motivation to use the application regardless of the training. The implication of this study indicates the need for similar training sessions regarding teachers' readiness to utilize adaptive learning digital applications and the

acceptance and willingness to implement them in science education. They also provide us valuable info for comparison during their use in the classroom afterwards.

385 Development and Implementation of a Robotic Activity Through BBC MicroBit for Teaching Electricity to 5th Graders

Effransia Tzagarakis, Stamatios Papadakis, Michail Kalogiannakis

University of Crete, Rethymnon, Greece

Abstract

This research examines whether teaching with the proposed application of educational robotics improves the academic performance of the students to a greater extent than the traditional teaching of electricity for students in the 5th grade. It also examines whether their attitudes towards physics are affected after having been taught using the Activity. To achieve this goal, a Teaching Learning Sequence (TLS) was designed and implemented. A quasi-experimental design with a pre-test and a post-test was used. 32 participants were involved. The research instruments used were two questionnaires. In spite of the small sample size, some interesting results were obtained. The experimental group performed significantly better overall, it turned out. The children's view of the importance of physics was not significantly affected in either group. However, there was an increase in the children's interest in the subject. The results of the research, when it is completed, will contribute to research that focuses on designing educational programmes, focusing on the pedagogy of science and STEM courses, as well as the use of educational robotics in the classroom.

386 The Role and Impact of Virtual Laboratories in Enriching and Transforming Laboratory Work in Physics Education

Dimitris Psillos

Aristotle University of Thessaloniki, Thessaloniki, Greece

Abstract

Physical laboratories (PLs) are conventionally used at schools and universities, yet virtual laboratories (VLs) are spreading out in curricula and teaching practices, due to their powerful and increasing affordances. The purpose of this paper is to discuss empirical studies published mainly since 2010 concerning the integration of VLs in physics teaching and learning, outline findings and their implications, identify open issues and provide suggestions for further research. A qualitative approach is applied for critical examination of empirical studies which promotes an in-depth discussion of the contribution and pedagogical exploitation of VLs for providing meaningful learning experiences to students at all levels of education. The impact of the use of VLs on students' conceptual learning, development of scientific skills, attitudes, and perceptions of their experiences is revealed and discussed. We elaborate on the role of VLs in enriching and transforming the experimental field, the representation of concepts and models,

data handling and facilitated linking of scientific theories with practices on behalf of users. It is argued that VLs have the capacity to change, enrich and transform laboratory work.

403 STEM Based Astronomy Activities with Ancient Minoan Analogue Computer

Apostolos Xenakis[1], Christos Xenakis[2], Sarantos Psycharis[3], Konstantinos Kalovrektis[1]

[1]University of Thessaly, Volos, Greece. [2]Astronomy and Space Society, Volot, Greece. [3]School of Pedagogical and Technological Education, Athens, Greece

Abstract

The period of the Minoan Civilization, the first great European Civilization, lasted from 3000 BC. until 1000 BC approximately. During this long period, shipping, agriculture and rural economy, water supply and drainage in large Palace structures, metallurgy and metalwork, pottery and seal carving, the art and color aesthetics of wall paintings, ceramics painting, lithography, micro sculpture and micro plastic were developed. In addition to the above, very important milestone is the development of Minoan scripting language, that is the Phaistos hieroglyphs, Linear A, and B. However, the less known achievements, but also very important has to do with the numbering system, the use of fractions with the analogical symbols, as well as the design and use of the first Analogue Computer, a radial small dimensions disk, the size of a palm, whose matrix is found in the location of «Paleokastro», near Sitia city in Crete. The use of this computer is multifaceted, because it functioned as a sundial, as a navigation instrument for finding the latitude of a place and as a system for predicting eclipses of the Sun and Moon! In this paper, we give background information related to the functionality and use of the analogue computer, as a scientific instrument, and we propose appropriate STEM Astronomy activities, which are supported by it. To this end, we argue to what extent, ancient Greeks did apply STEM. Our work focuses to measure the impact of using Minoan computer to the learning curve of students, working with Astronomy problems.

546 TPACK in Physics Education

Mehmet Fatih Tasar[1,2], Duygu Yilmaz Ergul[2]

[1]Georgia State University, Atlanta, GA, USA. [2]Gazi University, Ankara, Turkey

Abstract

This review of the literature identified earlier work related to Technological Pedagogical Content Knowledge (TPACK) even before the name was coined and then developing new literature in the new millennium. Today TPACK is mostly regarded as related to utilization of ICTs in instruction. However, as teaching during the covid-19 pandemic taught us once more TPACK encompasses also learning management systems. With the advance of microcomputers early in the 70's and 80's physics education researchers noted they potential novel contributions to student learning and how they could be utilized for tracking of progress in

student learning and as a tool for tutoring. Today we see that in physics education laboratory instruction is used to provide first hand experience of the physical phenomena being investigated and that laboratories are equipped with tools, devices, sensors, interfaces, and apparatus, that are connected to microcomputers for precise data collection and analysis. All of these have evolved from earlier analog versions to varying degrees of digital ones. Therefore, physics educators at all levels need to possess and develop TPACK and related skills for successful teaching and improved student learning and achievement. It should also be noted that not all attempts to include technologies yield desired results. The need for scholarship and further research is highlighted in this presentation by portraying the current status of the TPACK literature in PER.

Parallel Session - 6.11 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

32 The Development of Critical Thinking In Teaching And Learning Contexts That Focus on Health and The Environment

Chair

Leticia Garcia-Romano

Discussant

Marta Romero-Ariza

Abstract

Nowadays, we are experiencing a period of setbacks in terms of democracy, human rights, social justice and people's well-being, societies, and the environment (Reis, 2021). Given these circumstances, we are facing different forms of violence and systematic violations of human rights embedded in a global context characterised by a political as well as an environmental crisis (Valladares, 2021). Such context, worsened by the COVID-19 pandemic, poses countless challenges for science education. Puig, Blanco-Anaya and Pérez-Maceira (2021) argue that, although hardly anyone questions the role of critical thinking in the education of active citizens, science teaching in schools continues to be focused on "what to think" and, to a lesser extent, on "how to think." From this perspective, we claim that the development of critical thinking should be aimed at empowering citizens, with the purpose of achieving an active and informed participation in the processes of decision-making and action-taking (individually and collectively) regarding the problems that affect our communities (Reis, 2021). This symposium focuses on the development of critical thinking in different teaching and learning contexts linked to health and the environment. Therefore, our focus is on the concept of critical thinking as a dialogical practice that includes both purposeful judgment as well as civic participation and social justice (Jiménez-Aleixandre & Puig, 2022; Kuhn, 2019). Consequently, this set of papers presents research proposals developed on complex topics of high political and social

relevance such as immunology, biodiversity, genetics, and the dominant model of meat production and consumption. In this context, we address the link between critical thinking and different concepts which are at the core of science education, such as intersectionality, interdisciplinarity, citizenship, computational thinking, social activism, and teacher training. Furthermore, the symposium presents a variety of methodologies implemented, digital resources used, and educational levels analysed, from a perspective that highlights the potential of each context studied. The analysis of these studies will allow us to illustrate classroom experiences that adopt the practice of critical thinking as their main objective, it will offer an opportunity to provide conceptual relationships with topics that have been researched less extensively up to now and encourage us to revisit our role as educators who are committed to critical thinking.

250 Preservice Secondary Science Teachers' Teaching Proposals to Address a Socially Acute Question

Isabel María Cruz-Lorite[1], Nicolas Hervé[2], Daniel Cebrián-Robles[1], María del Carmen Acebal-Expósito[1]

[1]University of Malaga, Málaga, Andalucía, Spain. [2]École Nationale Supérieure de Formation de l'Enseignement Agricole, Toulouse-Auzeville, Haute-Garonne, France

Abstract

Teaching about socially acute questions seems beneficial for different aspects of student learning and its use in classrooms can be encouraged by including it in future teachers' training. This paper analyses teaching proposals made by preservice secondary teachers to address the socially acute question of the dominant model of meat production and consumption. The analysis was carried out in terms of the phases addressed for the inquiry and the conceptions of knowledge and pedagogical strategies adopted. The results show that the proposals are focused on information gathering and analysis, highlighting the controversies (engaged conception of knowledge) with the aim to develop critical thinking by teaching students to argue through the exploration of different positions on the SAQ (critical pedagogical strategies). The educational implications of these results are discussed in this work.

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253 Biodiversity Education and the Development of Critical Thinking for Brazilian Students

Marcelo Tadeu Motokane

University of São Paulo, Ribeirão Preto, São Paulo, Brazil

Abstract

The aim of this study is to show how the interdisciplinarity and the expansion of concept of citizenship are important factors to produce critical thinking and improve the quality of discussions on biodiversity. The data presented in this article come from the application of two

didactic sequences on biodiversity. The sequences were applied in two public schools in the region of Ribeirão Preto (São Paulo, Brazil). The data analysis methodology was based on the transcreation of students' conversations in the classroom. Data on citizenship come from a group of 8 17-year-old students who discussed the extinction of bees. Data on the contribution of interdisciplinarity were obtained by analyzing the conversations of a group of 10 12-year-old students who were preparing a theater play about managing bats in a city. The data presented show that working with interdisciplinarity expands the students' forms of expression and produces an engagement in the activity of learning more about the social and scientific aspects of biodiversity. Expanding the concept of citizenship shows students that to discuss biodiversity it is necessary to bring up issues of representativeness and rights.

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252 From Personal Teaching Experience to Student Engagement in Argument Construction in an Intersectional Critical Pedagogy Activity in Immunology Classes

Daniel Manzoni de Almeida

UBO, Brest, Bretagne, France

Abstract

The development of students' critical thinking in science classes is linked to the processes of socio-political-scientific engagement in teaching sequences. The aim of the present study was to promote students' critical argumentation in an immunology class that involved scientific knowledge in conjunction with intersectionality knowledge. The analyses showed that a large proportion of students questioned false statements that involved immunology knowledge and intersectional issues promoting student engagement in argument construction with the presence of epistemic and intersectional level diversity.

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254 Critical Thinking and Computational Thinking in the Learning of Socio-Scientific Issues Related to Genetics

Gimena Betina Fussero[1], Malena Villarruel-Parma[2], Maricel Occelli[1,2], Leticia Garcia-Romano[1,2]

[1]Science and Technology Teaching Department, National University Of Córdoba, Córdoba, Argentina. [2]National Scientific and Technical Research Council (CONICET), Córdoba, Argentina

Abstract

Critical thinking and computational thinking are extremely important skills in science teaching and learning. In this paper, we analysed the traits of critical thinking and computational thinking in the programming of short stories in Scratch with reference to cases of application of genetic engineering (GE) in a secondary school in the city of Córdoba, Argentina. The study was conducted using a design-based research approach. As for critical thinking, the projects done by the students included mainly arguments with evidence, data, and aspects that allowed for the assessment of information, as well as for the development of counterarguments. The main

computational thinking skills developed were parallelism and synchronization. Thus, it can be concluded that a context influenced by programming is suitable for making decisions about what to make visible, what information to represent and how to do it. In this way, it becomes an instance that fosters critical thinking and computational thinking traits.

Parallel Session - 6.12 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

57 Trust in Science and Science Education

Chair

Sibel Erduran

Discussant

Bill (William) Cobern

Abstract

Questions about trust in science have been with us since science and technology first began substantially influencing and altering our lives. Science and technology have certainly improved the conditions of human health and wellbeing, but sadly, they have also been detrimental and damaging to many and in ways that are rarely acknowledged. Consequently, much effort has been invested in understanding the nature of our trust in science and scientists; the practices, norms, values, and institutions that develop and support trust in science; and importantly, the consequences that the presence and absence of trust in science have on the wellbeing of everyone, but especially the vulnerable and marginalised. Likewise, much attention has been given to role that science education plays in mediating between science and society and therefore in setting the conditions for trusting science. In recent decades the question of why we ought to trust science, and how best to secure that trust, has returned to prominence, largely because of significant global and inter-generational concerns the severity of which science has both revealed and provided grounds for appropriate responses. Anthropogenic global climate change is a seminal example of such an issue, but more recently the COVID-19 pandemic has also stimulated renewed debate and discussion about the importance of trust in science, and by extension, institutions, experts, and governing agencies. The COVID-19 pandemic had major and lasting physical, social, psychological, economic, political, and educational consequences that have raised important and challenging questions about the role of science in society. This is understandable given that plural and often conflicting positions taken up within and across communities about the science, but also given the uneven and inequitable distribution of the best and worst of these consequences. Given these heightened concerns about trust in science and science education, this symposium seeks to explore the kind of scientific information and education that is made available to the public (formally and informally), the way this informs people's actions and attitudes, and the way this knowledge and

information is applied and manifested though forms of reasoning, justification, and rationality that are appropriate to science. Additionally, it examines the question of trust in science within a landscape of information, disinformation, and misinformation shaped by new media and often characterised by polarizing power and political discourses. Moreover, the complexity of experiences like the COVID-19 pandemic allows a re-examination of our unquestioned assumptions about science, its trustworthiness, its degrees of transparency, inclusivity, and neutrality. This symposium was inspired by a recent Special Issue on 'Trust in Science and Science Education' in the journal Science and Education (Erduran, 2022a; 2022b). This symposium similarly gathers distinctive but related perspectives on the topic of trust in science. It also brings together a plurality of theoretical and empirical approaches to the topic. For instance, one paper presents empirical work exploring the relationship between trust and non-trust participants' health-related behaviours, sources of information and categories of justification. Meanwhile, two other presentations take complementary theoretical approaches to examining rationality with respect to trust in science: the one is concerned with critical rationality in the context of Karl Popper's social and political theory; and the other with respect to the way differ educational 'spaces' (formal, informal and casual) preference different kinds of rationality and judgement (and hence different modes of trust). The fourth presentation instead critically examines the relationship between conceptions of trust, science, technology, and education in light of bias, racism and access: and in doing so makes recommendations for more a more equitable and socially just science education. All the contributors address the implication of their original research on science, education and society.

623 Re-Constructing the "Black" Box and Making It Transparent for the Future of Science and Technology in Science Education: Towards Equitable, Social Justice Criticality

Noemi Waight[1], Shakhnoza Kayumova[2], Jennifer Tripp[3], Feyza Achilova[4]

[1]University at Buffalo, Buffalo, NY, USA. [2]University of Massachussetts Dartmouth, Dartmouth, Massachussets, USA. [3]Buffalo Public Schools, Buffalo, NY, USA. [4]Brown University, Providence, Rhode Island, USA

Abstract

The dual benefits/challenges of science and technology—the rapid emergence of COVID-19 vaccines—was equally lauded and decried. Simultaneously, deficit-based narratives of vaccine hesitancy and mistrust in science and medicine by the general public and specifically people of color, became the norm. In this paper, we argue for a counternarrative, where instead of erroneously positioning communities of color as the problem, the problem is reframed to consider what the scientific, technological, and science education communities need to do to become trustworthy and transgress the persistent shortcomings related to racism and injustice. We discuss the interactions of science and technology from the perspective of the nature of technology; engage understandings of how bias, access, and racism operate in and at the

intersection of science and technology; and pose recommendations to counter mistrust with emphasis on equitable, social justice criticality, for science-technology education.

625 Trust in the Third Space of Science Education

Victoria Millar, Maurizio Toscano

University of Melbourne, Melbourne, VIC, Australia

Abstract

This paper investigates rationality and its relationship to trust in science in the context of three proposed spaces of science education: the formal, informal and casual. It begins with the place of science as a trusted institution and its role in formal and informal education across the world. Through educational systems, we have come to trust that students are being educated about science and its trustworthiness. However, formal and informal education spaces are not the only spaces in which individuals and society seek science understanding. While the science education literature has long concerned itself with science education in these spaces, this paper proposes a third space, the casual space. The casual space is decentralised and provides access to a range of norms and explanations about the world. We investigate how each of the formal, informal and casual spaces privileges particular forms of rationality as a means for understanding trust in science in each of these spaces. This paper considers the implications for education's response to the challenge of equipping students to make rational judgements about science.

648 Exploring the Information Sources and Justifications of Health-Related Behaviours in the Context of COVID-19

Ebru Zeynep Mugaloglu[1], Zeynep Kaymaz[1], Muhammet Emin Mısır[2], Canan Laçin-Şimşek[2]

[1]Bogazici University, Istanbul, Turkey. [2]Sakarya Universitesi, Sakarya, Turkey

Abstract

The COVID-19 pandemic highlighted the importance of trust in scientists, especially in science-related issues such as vaccination. The study aimed to explore sources of information and justifications of health-related behaviours of participants who trusted and those who did not trust scientists about getting the COVID-19 vaccine. An online survey was shared on social media, and the responses of 1233 participants from Turkey were analysed. The results showed that scientists were found to be the primary source of information for the trust group whereas non-trust group referred to Ministry of Health and media/social media as their primary information source. Moreover, seven categories emerged from the analysis of the justifications of the participants. Both groups justified their health-related behaviours mainly by referring to science-, policy, and citizenship-related categories. Trust issues also appeared under these categories in both groups. The study highlighted the need for scientifically informed citizens not to jeopardise effective solutions to eliminate the pandemic, e.g., getting the vaccine.

651 Critical Rationalism and Trust in Science

Adam Chmielewski

University of Wrocław, Wrocław, Poland

Abstract

My aim is to consider whether the critical rationalist philosophy of science may provide a rationale for trusting scientific knowledge. I shall refer to several insights of Karl Popper's social and political philosophy in order to see whether they may be of help in offsetting the distrust of science spawned by the Covid-19 pandemic and to address a more general issue of whether the theoretical principles of the critical rationalist philosophy of science may afford a foundation for building trust in science. In conclusion, I argue that: critical rationalism views science as a cognitive regime which calls for bold theories and at the same time demands a rigorous and continuous distrust towards them, and it is precisely this attitude that should be adopted as a compelling argument for trusting science.

Parallel Session - 6.13 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

49 How Low Can You Go: Comparing National and Disciplinary Standards to Learn About Appropriate Levels of Abstraction in Inquiry

Chairs

Arne Bewersdorff, Daniel Capps

Discussant

Anat Zohar

Abstract

Inquiry-based instruction has been an elusive ideal in classrooms throughout the globe for decades. Most simply, it can be thought of as a teaching strategy that provides students with opportunities to work and think like scientists. However, this definition quickly becomes insufficient when one begins to consider the diversity of practices in science, cultural differences in how it is practiced, progressions for learning to engage in science, etcetera. In this symposium, we explore different ways inquiry is framed both across disciplines and nations, to understand why inquiry has remained elusive and what we can learn about its framing to support greater uptake of inquiry instruction globally. This session includes presenters from: South Africa, Vietnam, Germany, Georgia, Turkey, and the United States. Presenters will give a brief overview of the science standards in their country, describe how inquiry-based instruction

is conceptualized, and discuss the level of abstraction by which it is portrayed, both in terms of its domain generality and its flexibility within a domain. In what follows, we provide a brief discussion of the findings which will be expanded upon in the symposium by the discussant, an expert on inquiry-based instruction from Israel. Each of the countries has a set of national standards; however, in both Germany and the US, instruction is governed by state level standards, making the national standards more guidelines than requirements. A central feature of each curriculum is an emphasis on student-centered pedagogies, like inquiry-based instruction. Inquiry itself is prominent in each country's standards. Georgia, Vietnam and Turkey list it alongside other student-centered instructional approaches like problem-based learning, project-based learning, and learning by doing. However, only standards from the US provide a definition of inquiry-based instruction via the essential features of inquiry or the scientific practices. We see curricula existing along a continuum from domain general to domain specific and there are clear differences in methods of science that are highlighted in the curricula. Most paint an image of inquiry that is domain-specific. For instance, Germany describes a set of competencies particular to each subject students should learn, whereas Vietnam is even more specific, providing a set of process skills in given disciplines. This is similar for all other countries, to some degree, except for the US, which conceptualizes inquiry in the abstract only, via a set of practices. All of the curricula name experimentation as a method of inquiry, but some appear to give it special status (e.g., Germany and Vietnam). Thinking across the curricula, the lack of a clear definition of inquiry-based instruction is problematic (and a barrier to enactment), as many teachers will not then have adequate understanding of what inquiry is and precisely what it entails. The focus on domain-specific competencies, which seems to be common in many countries, might help teachers bring inquiry (or inquiry skills) into their teaching; however, it might add to the conception that each science has its own set of methods. On the other hand, the generalized list of practices from the US might be challenging for teachers to follow, particularly for those who lack experience with inquiry, as it would require them to instantiate these practices on a discipline. We argue that teachers will likely need both an abstract rendering of inquiry and more contextualized competencies geared towards specific disciplines to truly enact it in the classroom. Overall, these findings highlight the need for greater emphasis about how inquiry-based instruction is conceptualized in different countries. This could lead to an enhanced understanding of the capabilities and limitations of research in the field and shape the next round of science curricula reform.

764 Georgian and German Understanding of Inquiry: Findings From Their National Curriculums

Arne Bewersdorff[1], Marika Kapanadze[2]

[1]Technical University of Munich, Munich, Germany. [2]Ilia State University, Tbilisi, Georgia

Abstract

This presented summary gives insight into the Georgian and the German science curriculum. Despite the fact that the German curriculum and the Georgian curriculum developed under

different historical circumstances, there are some similarities in the current curricula. Apparent are the domain specificity of the scientific practices or competencies as well as the focus on experimentation as one method of inquiry. Both countries put emphasis into inquiry-oriented instruction but do not provide a clear definition of inquiry for natural sciences in general. In Georgia the design of assessment at the end of school might act contrary to this endeavor by not focusing on inquiry like stated in the curriculum in reality. The findings will be discussed within a broader perspective during the ESERA symposium, featuring authors from the United States, South Africa, Vietnam, and Turkey.

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810 Turkish Science Curriculum: Advancing Towards Fostering Inquiry

Günkut Mesci

Giresun University, Giresun, Turkey

Abstract

The main purpose of science education in Turkey is to raise scientifically literate individuals. In this sense, it is clearly stated in the science program put into practice in Turkey in 2018, "the science course is designed based on inquiry-based instructional approach with an interdisciplinary perspective in order to create meaningful and permanent learning through student-centered activities like projects, inquiry and research experiments". Although the term "inquiry" is not explicitly mentioned in the standards, scientific process skills, life skills, and engineering-design skills are contextually included in all science subjects.

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964 Perspectives on “Inquiry” in the United States Science Curricula

Daniel Capps

University of Georgia, Athens, GA, USA

Abstract

Inquiry-based instruction has been a goal for science teaching in the United States for over two decades. Two different reform movements have refined the conception of inquiry from a set of essential features to a series of scientific practices, both meant to apply broadly across science disciplines. However, wide-spread enactment of inquiry has remained somewhat elusive. Here, I argue that the concept of inquiry in the US may be too abstract, lacking important disciplinary conceptualizations (i.e., grounding) that classroom teachers need to enact inquiry within their particular disciplines.

1093 Vietnam and South African Science Curriculum: Inquiry as a Structured Process

Umesh Ramnarain[1], Hong Tran[2]

[1]University of Johannesburg, Johannesburg, South Africa. [2]University of Georgia, Athens, Georgia, USA

Abstract

The latest science curriculum standards in Vietnam and South Africa both aim to emphasize practical skills. Whereas South Africa makes explicit reference to inquiry instruction, Vietnam only does so implicitly in the standards. The Vietnamese curriculum restricts teachers to a fairly specific approach, emphasizing a sequence of steps. Meanwhile, the South African curriculum includes scientific inquiry as a key goal, but the meaning is not clearly defined. Across both countries' standards inquiry instruction is inadequately communicated through the listing of science process skills that can be addressed through inquiry. An analysis of curricular documents for the school subjects, Life Sciences, Physical Sciences and Natural Sciences reflects that there is a lack of disciplinary specification for inquiry.

Parallel Session - 6.14 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

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51 Balancing Disciplinary and Interdisciplinary Competences: Theoretical and Empirical Results of the Design of Modules for Teacher Education

Chairs

Laura Branchetti, Olivia Levrini, Eleonora Barelli

Discussant

Shulamit Kapon

Abstract

Interdisciplinarity, after a long period of practice, turned now into a real research strand deserving theoretical efforts to define what it can mean in science and STEM education, recognize if and how interdisciplinary knowledge and skills are developed in teaching, and analyse what contribution it can provide to regenerate science and mathematics education. In this symposium, four studies are presented as outcomes of a European project aimed to develop an approach to design interdisciplinary teaching modules for preservice teacher education (PTE). The first paper of the symposium is theoretical. It presents the theoretical framework that has been progressively and iteratively developed for STEM education through a back-and-forth process of module-design, implementation, and analysis. The framework comprises both theoretical principles for the approach to interdisciplinarity and a didactical

model to design modules for PTE. As for the approach to interdisciplinarity, it operationalises the basic principle that interdisciplinarity is not a-disciplinary but a way to exploit the epistemological core of disciplinary identities, when they are confronted and recognised in boundary zones (Akkerman & Bakker, 2011; Klein, 2010). As for the didactical model for PTE, the framework is an adaptation for interdisciplinarity of the model known as "Study and research paths for teacher education" (Barquero et al., 2018). The other three papers are empirical and concern implementations of two different types of modules, one regarding curricular interdisciplinarity, the other about interdisciplinarity in emerging STEM topics. All the modules have been implemented in local contexts and in international summer schools (ISSs) and iteratively revised on the basis of empirical results. All the research approaches are qualitative or semi-qualitative, being the scope of the analyses mainly theoretical. Consistently, the three presentations will provide a special emphasis on their contribution to the development or clarification of the theoretical framework. The second paper concerns the curricular topic of parabola and parabolic motion. The data analysed were collected during the module's implementation within a university physics education course. The main results show that the approach developed within the project shaped a complex learning space where there was room for different attitudes toward interdisciplinarirty: from prospective teachers who feel better within the disciplines' identity cores, to those who like to inhabit boundary zones, and to who likes to re-shape boundary spaces and move dynamically across them. The third paper concerns the emerging STEM theme of nanotechnology. The data analysed were collected during the module's implementation at the project's first ISS. The main results show that for the development of an interdisciplinary module is important to take into consideration that specific boundary objects enlighten specific aspects of their ambiguous nature while it is also important to focus on prospective teachers' disciplinary identity, given that prospective teachers with different backgrounds recognize different aspects of the ambiguous nature of boundary objects. The fourth paper focuses on the identification of the constraints and limitations that hinder the realization of interdisciplinarity in secondary education. It first considers prospective teachers' reactions to the implementation of a module on COVID-19 evolution during the project's first ISS. Then it includes broader reflections of the participants in the second ISS on the tensions experienced when imagining transpositions of interdisciplinary experiences in secondary schools. The results point out both personal limitations, such as the mastery of content knowledge, and external limitations, such as the barriers imposed by educational systems. On the basis of the four presentations, the Discussant will point out the complementary contributions to the theoretical reflection on interdisciplinarity and will point out the open issues requiring further investigation.

553 Epistemological Issues in Interdisciplinary Teacher Education: Curricular Topics and Emerging Fields

Argyris Nipyrakis[1,2], Laura Branchetti[3]

[1]University of Crete, Rethymnon, Greece. [2]University of Groningen, Groningen, Netherlands. [3]University of Milan, Milan, Italy

Abstract

Policy reports call for the design and implementation of interdisciplinary (ID) curricula for teacher education. However, little is known about how to apply existing theoretical frameworks for ID teaching and how design-based research can inform the refinement of such frameworks and provide recommendations for ID teacher education. The present study, based on the project outputs of a cross-national academic partnership, proposes a model of interdisciplinarity for teacher education consisting of: a) design methodologies for teaching modules in both curricular topics and emerging fields, b) theoretical constructs that may assist the identification and the analysis of interconnections among disciplines. Implications for the literature on epistemology and task design in ID teacher education are discussed.

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695 Shaping New Boundaries Between Physics and Mathematics: Interdisciplinarity in the Case of Parabola and Parabolic Motion

Sara Satanassi[1], Rachele Casarotto[1], Eleonora Barelli[1], Laura Branchetti[2], Martina Caramaschi[1], Paola Fantini[1], Olivia Levrini[1]

[1]Department of Physics and Astronomy, Universtiy of Bologna, Bologna, Italy. [2]Dipartimento di Matematica, Università degli Studi di Milano Statale, Milano, Italy

Abstract

In this contribution, we discuss the results of the implementation of an interdisciplinary module on parabola and parabolic motion involving about 57 mathematics and physics prospective teachers. The module was designed to restore and revive the relationship between physics and mathematics in two historical interdisciplinary episodes in which the disciplines are usually treated as separate enclaves. In order to flesh out this relationship, we develop an approach aimed to value both disciplines' epistemological identities and the mechanisms for their integration. Two frameworks were chosen to reflect on both "sides" of inter-disciplinarity: the Family Resemblance Approach (FRA) to reflect on differences and similarities between disciplinary identities, and the boundary objects and boundary crossing mechanisms to investigate the mechanisms of integration and dialogue. The study aims to investigate what kind of attitudes students have toward interdisciplinarity and what reasoning about disciplinary identities and crossing disciplinary boundaries in an interdisciplinary context the approach can promote. The data analysis shows that the combination of the two frameworks shaped a complex learning space where there was room for very different epistemic demands: from prospective teachers who feel better within the identity cores of the disciplines, to those who like to inhabit the boundary zone, and to who likes to re-shape boundary spaces and move dynamically across them.

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748 Pre-Service Teachers' Perspectives on Boundary Objects in a Nanotechnology Module.

Chara Bitsaki[1], Athanasia Kokolaki[1], Argyris Nipyrakis[1], Ioannis Metaxas[2], Emily Michailidi[1], Dimitris Stavrou[1]

[1]University of Crete, Rethymnon, Greece. [2]University of Crete, Heraklion, Greece

Abstract

Integration of skills and knowledge derived from more than one discipline is a necessity that springs from the interdisciplinary nature of real-world problems and the ways to face them. This paper presents the implementation of the boundary objects framework in order to develop an interdisciplinary module on nanotechnology, that explicitly highlights crosscutting concepts, methods and artifacts. Pre-service teachers discuss aspects of the ambiguous nature of boundary objects that express both their multivoicedness and unspecified nature. According to the results of this study, pre-service teachers recognize the aforementioned aspects in relation to their disciplinary identity. Also, specific boundary objects enlighten specific aspects of their ambiguous nature. Considerations for the development of interdisciplinary modules are provided.

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556 Dealing With Constraints for Interdisciplinarity: Experiences With Preservice Teacher Education

Carolina Pipitone[1], Berta Barquero[1], Eleonora Barelli[2]

[1]University of Barcelona, Barcelona, Spain. [2]University of Bologna, Bologna, Italy

Abstract

This paper focuses on the general problem of analysing the kinds of tensions and constraints that hinder interdisciplinarity (ID) to be realized in secondary school education, and the inevitable steps of the professional development of teachers to deal with them. Based on the proposal of the study and research paths for teacher education (SRP-TE), as elaborated in the framework of the anthropological theory of the didactic, we present our collaborative experience with the design and implementation of instructional modules about curricular and emergent ID. First, we focus on the case of two implementations of an SRP-TE about the role of models, modelling, and simulation in understanding COVID-19 evolution. The results show how participants, preservice secondary school teachers from 4 different countries, progress in the critical issue of experiencing and identifying constraints hindering ID and the conditions that were created to start dealing with them. Secondly, we extend the results with the implementation of the COVID-19 module, with the more general reactions of participants in an International Summer School where they had experienced different modules about ID.

Parallel Session - 6.15 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

20 Teaching Chemistry During and Beyond the COVID-19 Pandemic

Chair

Aybuke Pabuccu Akis

Discussant

Ron Blonder

Abstract

The onset of the COVID-19 pandemic has brought forth a major shift in society as well as in the educational landscape. Educators have faced new challenges in their teaching, and new questions emerged for chemistry teaching and learning. For example, how can students carry out chemistry experiments at home? How can new technological tools, such as augmented reality, and platforms such as virtual reality support chemistry education? To overcome these hurdles, chemistry educators around the world have had to rapidly develop innovative learning options for foundational chemistry courses and laboratory experiments. Furthermore, the COVID-19 pandemic has had a significant impact on research in chemistry education (CER). Recent CER studies highlight diverse challenges and opportunities in teaching chemistry remotely. This paper set brings together four studies to contribute to the recent literature to help inform policymakers, schools, and researchers by investigating the effects of the pandemic on chemistry education research and practice. The presenters are from four countries (USA, Israel, Turkey, and UK) and contribute towards an understanding of the following questions: (1) How has the COVID-19 pandemic changed chemistry teaching and how will it affect it in the future?, and (2) How COVID-19 affects research in chemistry education? Studies 1 and 2 address the first question of the symposium. Study 1 introduces major changes observed in chemistry teaching, identifies areas in which educational changes were limited, and discusses major reforms still needed to address educational challenges made explicit as a result of the pandemic. Study 2 discusses teachers' challenges in teaching chemistry during the pandemic, as well as their positive experiences through the teachers' perspective. Studies 3 and 4 focus on the second question and explore how CER studies are affected by the pandemic. Study 3 reviews recent research on a selected set of themes (nature of chemistry, argumentation, technology, STEM education) in an effort to identify how some CER areas have developed since the emergence of the pandemic. Data were obtained from the analysis of 659 research papers. Study 4 examines the ways how technology was integrated into chemistry teaching during the pandemic. The researchers reviewed CER papers published in international journals indexed by the Web of Science. 183 research papers were subject to bibliometric analysis and content analysis. This review shows that technology has been an integral part of chemistry education. The paper set will attract a wide audience of ESERA members interested in the effects of the pandemic on science teaching and educational research. Discussing the lessons learned in

teaching chemistry remotely opens opportunities to identify needed reforms in curriculum, instruction, and assessment to address the challenges made explicit by the pandemic. Considering the challenges experienced in face-to-face teaching as well as the limitations of online learning environments, it is anticipated that the future of chemistry education will involve a mix of both, for example, through flipped learning approaches. The symposium will also highlight how the pandemic opened opportunities for students and teachers. It encouraged students to become independent learners and created opportunities for teachers to enhance their technological pedagogical content knowledge. This symposium will contribute to identifying where further research may be needed given the changing circumstances. For instance, educational experiences during the pandemic raised questions about diversity, equity, and inclusion that remain unresolved and are likely to be major areas of interest in the near future.

108 What Changed, and Didn't, in Chemistry Teaching as a Result of the Covid-19 Pandemic?

Vicente Talanquer

University of Arizona, Tucson, Arizona, USA

Abstract

In this critical perspective, I will describe and discuss major changes observed in the areas of curriculum, instruction, and assessment in chemistry education induced by the COVID-19 pandemic. I will also identify areas in which educational changes were more limited, and discuss major reforms still needed to address major educational challenges made explicit by the pandemic. Major insights will be derived from the analysis of published educational innovations and studies on chemistry teaching and learning experiences during and after the COVID-19 pandemic.

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109 Leaving the Comfort Zone: How Has Covid-19 Changed the Way of Teaching in Chemistry Education Now and Will Most Probably Change in the Future?

Rachel Mamlok-Naaman, Debora Marchak, Sara Akons

Weizmann Institute of Science, Rehovot, Israel

Abstract

The outbreak of the Covid-19 at the first third of 2020 caused a change in our lives in many ways. The distance learning, consisting of using technological tools, required changing both the teachers' knowledge of educational technology, as well as and their beliefs, stands, and pedagogical perceptions. However, studies indicate that going beyond the limits of comfort encourages growth – developing new skills, enriching our lives, and engaging in new ideas. This paper refers to a case study in the framework of a professional learning communities (PLC)

program, in which 20 chemistry teachers described their challenges during the Covid-19 pandemic, as well as their adaptation to the situation, with the emphasis on their professional development growth, and other benefits - points of light. The two leaders of the workshop asked each teacher to write down an essay about their challenges in teaching chemistry during the Covid-19, as well as their positive experiences. The researcher of this study analysed the essays, and after categorizing the answers, they interviewed the teachers in order to triangulate the data obtained from the essays. The categorization of the essays showed three groups: adaptation of new teaching strategies, development of an independent learner, and acquaintance with lessons' recording the lessons. The categories were discussed with the teachers in one of the PLC meetings. In summary, the Covid-19 pandemic promoted emergent remote education, which on one side challenged chemistry teachers and students, and on the other side, encouraged them to leave their comfort zone, and develop in new innovative directions. Most of the chemistry teachers claimed that during this period they felt that their professional – pedagogical, scientific and technological development had strengthened. They expanded the diversity of teaching methods, and encouraged students to become independent learners. We will refer to a few examples during the presentation

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107 How Chemistry Education Research Has Responded to the Demands of the Pandemic Context?

Aybuke Pabuccu Akis[1], Sibel Erduran[2]

[1]Dokuz Eylul University, İzmir, Turkey. [2]University of Oxford, Oxford, United Kingdom

Abstract

This paper review recent research on a selected set of themes (nature of chemistry, argumentation, technology, STEM) in an effort to identify how some example areas of Chemistry Education Research (CER) have developed in recent years and particularly since the emergence of the COVID-19 pandemic. Considering the magnitude of the pandemic and its impact on education, our intention is to highlight the landscape of CER that has increasing relevance and to problematize where further research may be needed given the changing circumstances. We are motivated by the need to explore how CER has responded to the demands of the pandemic context, and as such, it has put into question how chemistry education is treating understanding of what chemistry is about and how evidence-based reasoning works in chemistry. Hence, we are guided by the need to explore the extent to which CER has investigated understanding of what chemistry is about (i.e., nature of chemistry) and how evidence-based reasoning (i.e., argumentation) works in chemistry. Furthermore, the pandemic context has led to a significant uptake of technological tools to facilitate the teaching and learning of chemistry as educational institutions switched to online learning environments. Before the COVID-19 pandemic, no one could have anticipated such a tremendous amount of rapid change that led to the implementation of more technological tools by more chemistry teachers. Finally, the pandemic context has put into question how interdisciplinary and complex problem solving can be integrated in STEM education. Chemistry is a discipline that sits at the interface of science, technology, engineering, mathematics, and medicine (STEMM) subjects. Therefore, chemistry

education research has placed an emphasis on STEM teaching and learning. Results shows that argumentation, technology, and STEM education have gained increasing popularity, while nature of chemistry has been reported to be lagging behind in CER.

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110 Technology Integration into Teaching Chemistry During the COVID-19 Pandemic

Mustafa Sözbilir, Dilek Teke

Ataturk University, Erzurum, Turkey

Abstract

This study aimed to investigate the ways technology is integrated into the chemistry teaching during the Covid-19 pandemic. The papers published in international journals indexed by Web of Science (WoS) in chemistry education are examined and the prominent areas of chemistry, pedagogy, target audiences, technologies, countries and organizations are determined. A search on WoS resulted 183 research papers (articles & reviews only). The collected papers are subjected to bibliometric analysis and content analysis. Bibliometric analysis was done to identify the common chemistry topics or sub-topics studied, pedagogies employed, target audiences, technologies, countries and organizations. In addition, the research approaches & designs, data collection tools, sample size, and types of data analysis used in the method section of the research papers were also examined via descriptive content analysis. The results obtained are shown that prominent journal is the Journal of Chemistry Education, and the studies consisting of organic chemistry and laboratory instruction were the most common. In addition, distance learning/self-instruction, internet/web-based learning are the technologies that come to the fore in these studies. The studies are mostly conducted in the USA and the target audience consisted of undergraduates

Parallel Session - 6.16 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

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68 Sig1- Current Trends in Early Years Science Education

Chair

Estelle Blanquet

Discussant

Christine Tippett

Abstract

Science education for young children has become an issue in many countries over the past decades. It is now increasingly common to find programmes that include science education from an early age, whether in kindrgarten or in other structures. However, early years science education research is still in its infancy, both about the development of concepts by young children and about their relation to the scientific method. The same applies to research on approaches likely to best help teachers to support and train their pupils in science, in part due to the important variations in constraints, expectations and context from one country to another. The previous Early Years Science invited symposium explored various aspects of the nature of science at early years. This time, we have chosen to consider different aspects of the field, including papers from four countries with very different educational systems: the United States, Greece, Australia and Finland. The four communications that are proposed therefore address four distinct themes. - The ability of kindergarten pupils to explain states of matter and phase changes through particle models of matter, by engaging them in modeling-based, technology-mediated science inquiry. This experimental study conducted in six kindergarten classrooms includes individual interviews with students before and after they completed the instructional unit and digitized copies of students' science notebook entries during learning. - The effectiveness of ScratchJr in promoting them computational thinking (CT)and basic coding skills in preschool children in a context where several different programming environments claim to be designed to this effect. The research addresses two questions: does a short-term educational intervention using the app ScratchJr promote computational thinking in preschool children?What basic CT concepts will preschoolers develop through a short-term educational intervention using the ScratchJr app? - The means to support teacher practice in early childhood science, with a specific focus on classroom quality, assessment, and playful learning during the implementation of science Games. Drawing on bio-ecological theory, classroom observations were conducted to measure the quality of classroom interactions that contribute to child learning; semi-structured interviews identified teachers' assessment practices, and the influences on these practices, during the implementation of the science games. - The Young children's task deviations during playful inquiry as task deviations have the potential to reveal what kind of knowledge children find meaningful to produce and unfold children's participation in scientific culture. This experimental study is based on a cultural-historical understanding of science education and Third Space theory and use videos of a teacher implementing a nine-week playful inquiry program with the children, consisting of nine inquiry-based science learning units embedded in stories and dramatic play. These four presentations will offer the possibility of exchanges on the very diverse research methods used and the results obtained from these different approaches, and more generally on the questions that cross current research on very young pupils.

1154 Australian Teacher Practice in Early Childhood Science: Play, Quality & Assessment

Cristina Guarrella

The University of Melbourne, Melbourne, Victoria, Australia

Abstract

Australian policy documents emphasise the importance of young children learning process skills typically associated with science, however existing mandated frameworks do not explicitly refer to science. This has led to teachers seeking professional learning to better equip them to embed science within an informal curriculum. The rollout of a suite of playful science games in preschools across one Australian territory provided the opportunity to conduct this intervention study. This research aimed to understand how to support teacher practice in early childhood science, with a specific focus on classroom quality, assessment, and playful learning during the implementation playful science Games. Drawing on bioecological theory, classroom observations were conducted to measure the quality of classroom interactions that contribute to child learning. Semistructured interviews identified teachers' assessment practices, and the influences on these practices, during the implementation of the science games. Based on the findings, this research recommends the following supports for teacher practice in early childhood science education: 1) professional learning to equip teachers to facilitate playful science learning; 2) learning progressions of science process skills; 3) implementation of the Assessment for Playful Learning model. Ultimately, when teachers are clear about what science learning is possible within playful experiences, they are better equipped to observe and assess children demonstrating what they know. This can inform authentic scaffolding and contingent planning for playful science teaching and learning.

1156 Underestimated Capabilities? Kindergarten Students' Emerging Particle Models of Matter to Explain Varied Material Phenomena

Ala Samarapungavan[1], Lynn Bryan[2]

[1]Purdue University, West Lafayette, Indiana, USA. [2]Purdue University, West Lafayette, IN, USA

Abstract

In this study, we examined kindergarten students' learning about the nature of matter in the context of model-based, technology-mediated inquiry science instruction. The goal of instruction was to help children learn to use simple particle models to explain states of matter and phase changes. We examined changes in kindergarteners' ideas about matter, the coherence of their emerging particulate models, and how classroom science discourse influenced student learning. We conducted the study in six kindergarten classrooms: four in a rural midwestern public school and two in metropolitan public schools in the northeast United States. Our data sources included individual interviews with students before and after they completed the instructional unit and digitized copies of students' science notebook entries during learning. Our research suggests that children as young as kindergarten can learn to use

simple particulate models to explain states of matter and phase changes. Through engaging in modeling-based, technology-mediated science inquiry, children developed more coherent particulate models to explain states of matter and phase changes. Our findings provide compelling evidence that young children can engage productively in learning core scientific ideas that will be critical to their future mastery of more advanced scientific concepts.

1171 Fostering Computational Thinking in Preschool Education With the Help of ScratchJr

Konstantina Louka, Stamatios Papadakis, Michail Kalogiannakis

University of Crete, Rethymnon, Greece

Abstract

Several different programming environments claim to be designed to teach computational thinking (CT) and coding skills to preschool children. However, research on their effectiveness is still in its infancy. Using a three-week didactic intervention, the present study investigated the effectiveness of ScratchJr in promoting CT and basic coding skills in preschool children (N=34, 4-6 years). Although the mean pretest performance of the control group (M=7.07, SD=2.58) was significantly higher than that of the experimental group (M=5.35, SD=1.58), $t(22.64) = 2.23$, $p=0.036$, the mean posttest performance of the two groups was approximately equal. However, data analysis revealed a statistically significant improvement in preschool children whose educational intervention included ScratchJr. The results support the effectiveness of the specific programming environment in developing CT and coding skills in preschool children.

1184 Young Children's Task Deviations During Playful Inquiry

Jenni Vartiainen

University of Helsinki, Helsinki, Finland

Abstract

This study aims to investigate young children's deviations from a task while working with playful inquiry activities. Previous studies have scrutinized children's participation in scientific literacy practices in inquiry-based learning from different perspectives, but children's participation in activities that follow task deviation is understudied. Task deviations have the potential to reveal what kind of knowledge children find meaningful to produce and unfold children's participation in scientific culture. A cultural-historical understanding of science education and Third Space theory underpins the study. Third Spaces are ways to bridge marginalized knowledge and discourses. Young children are not usually seen as capable agents who can participate in the culture of science and transform it; thus, their participation is marginalized. The video data (810 min) was collected from a group of kindergarten children (n=6, 4 - 5 -year-olds) and their teacher. The teacher implemented a nine-week playful inquiry program with the children, consisting of nine inquiry-based science learning units embedded in stories and dramatic play.

The video data was analyzed by multimodal interaction analysis. The findings show that three types of scripts emerge in Third Spaces between teacher's script and children's counter scripts: Merging scripts, Convergent scripts and, Parallel scripts. Merging scripts allow children to participate in scientific literacy practises from cultural, critical and operational perspectives, while other scripts neglect cultural and critical participation. The study highlights that in inquiry-based science education teacher and children form a learning community, and the power of deciding what knowledge is worth producing isn't owned by a teacher but is a result of negotiation and active merging of (counter)scripts.

Parallel Session - 6.17 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

50 Learning with and Transgressing Boundaries in Science Education

Chairs

Betzabe Torres Olave, Cristiano Barbosa de Moura

Discussant

Jesse Bazzul

Abstract

Initially thought of as mere dividers between school disciplines, crossing boundaries was seen as an opportunity to integrate disciplines in schools. Recently, however, boundaries started to be conceptualised more broadly as "sociocultural differences that give rise to discontinuities in interaction and action" (Akkerman & Bakker, 2011). Within this movement of investigating under the umbrella of "boundaries", there is a growing interest in moving out of disciplinary/institutional containers to cross borders and act upon complex societal challenges from pluralistic perspectives (Kayumova & Dou). In previous work, we argued the need to problematise boundaries, particularly reflecting on what is lost through the exclusionary and authoritative character of boundaries acting as "abyssal lines" (de Sousa Santos, 2018) that separate what is "here" and "there", hierarchising ways of knowing and being. With this symposium, however, we would like to look through the cracks of boundaries to understand and contest them, seeking reverberating acts that change cultures, inviting others to look for interstices for change through boundary work. In such interstices, we may find alternatives and potential light to develop new paths for science education. Examples of these boundary challenges are the integration of Indigenous knowledges in science education, the research-practice gap, and the gender gap in science and science education. In this symposium, we aim to explore some of these borders in terms of institutional, disciplinary, and identity boundaries. Such exploration may be a way of overcoming discrete units of analysis and illuminating new paths of understanding of how we relate to others across disciplines, contexts, and professions. Considering boundaries as places of learning that are ambiguous in nature, we seek to

interrogate boundaries in science education to unpack their complexities: What happens in/at boundaries? What can we learn with(in) boundaries? Considering the current state of affairs in society and science education, what kind of boundary-learning may contribute to justice-oriented science education? With that, we hope to open new avenues of research in science education that sees boundaries as places more than barriers, venues of passage or gaps, but as a location where a multitude of things (may) happen. This symposium gathers scholars located in Brazil, Australia, the US, Mexico, Canada, and the UK, working across boundaries. Authors1 share experiences navigating institutional and positional boundaries regarding their identities as teacher-researchers and the vision their borderland space offers for science teacher education and school science. Author2 uses the possibilities of working across contexts, making evident the need to problematise the border between school science and societal values through an analysis of biology textbooks. Author3 addresses the boundaries between human and more than human actors for analysing gender in educational settings, and the possibilities new materialism offers to recognise students' subjectivities in motion. Author4 works across ways of knowing to offer new epistemic possibilities for science education by providing a theoretical approach for epistemic brokering between indigenous epistemologies and modern western science and technologies. Collectively, these papers highlight, through different onto-epistemic boundary work, the tensions, but particularly the possibilities, to expand what counts as science education in terms of its practices, methodologies, and philosophies. As such, they invite researchers to reflect and move towards humble ways of learning and producing knowledge that contests the aforementioned abyssal lines of thinking/doing/being in science education.

501 A Posthuman Inquiry into How, Where And When Things Matter in The Actualization of Gender in a High School Biology Classroom

Sophia Jeong[1], Jesse Bazzul[2]

[1]The Ohio State University, Columbus, OH, USA. [2]University of Regina, Regina, Canada

Abstract

In this proposal, the author aims to describe the conditions under which the capacity of gender was actualized in a secondary biology classroom at a public high school in a Southeastern region of the United States. To this end, the author turns to posthuman perspectives that consider an onto-epistemological lens which decenters the human and instead foregrounds the co-constitutive and intra-active nature of the humans' relationships within the world (Author et al., 2021). Barad (2007) discusses the notion of entangled agencies where things and human exist in a state of mutual constitution, or intra-action. In so doing, through this intra-action, things and human are no longer the same as they were when they were alone; instead, they have become something different. The author of this proposal draws on scholars of new materialisms to explore how things mattered in the actualization of students' gender, which followed unpredictable lines of flight and in what gender could become. This empirical study investigates the concept of gender (following Derrida's sous rature) using new materialism

theories and offer possibilities for a new concept, students' subjectivities-in-motion in science education.

509 School Biology: Between Politics, Ideologies, and Science

Gonzalo Peñaloza[1], Betzabe Torres Olave[2]

[1]Centro de Investigación y de Estudios Avanzados del IPN - Unidad Monterrey, Monterrey, Nuevo León, Mexico. [2]University of Leeds, Leeds, United Kingdom

Abstract

Since the end of the nineteenth century, the inclusion of science in schools was key to the intention of modernity to form rational subjects. In this framework, science in schools was assumed as the result of an objective and neutral transposition/adaptation of scientific developments. This paper asks whether these assumptions are consistent with the development of biology in school. To address this question, Popkewitz's (1997) historical perspective on the Formation of School Subjects is used. Popkewitz argues that the inclusion and configuration of scientific disciplines in school do not only arise from a technical rationale, but it is the result of their conjunction with politics and ideologies, interacting in various ways in the field of education and culture. The study carries out a qualitative meta-analysis of studies dealing with biology textbooks from Colombia and Mexico, as a way to explore the boundary between school science and society, and how in this border curriculum is built. The analysis proposes that the inclusion and approach in school of some biological concepts and theories result from interactions between scientific reason and the political and ideological conditions of each context. In this sense, disciplinary contents are adjusted and modified to fit within the formation of a certain ideal subject. The study concludes that biology in school is not the simple result of a didactic transposition or an updating of contents, but that it expresses values, habits, desires, and socially desirable and acceptable forms of subjects.

570 "Being" the Boundary: Reflections From a Dialogue Between Two Teachers-Researchers

Cristiano Moura[1], Andreia Guerra[2]

[1]Simon Fraser University, Vancouver, Canada. [2]CEFET/RJ, Rio de Janeiro, Brazil

Abstract

Researchers in science education have been claiming a gap between research and practice in the field, since many results and innovations from research do not reach schools and science teachers' practice. However, what happens when high school science teachers are also researchers in science education? In this paper, we explore a place of being in-between academic research and high school teaching, analyzing its possibilities and challenges. Inspired by the principle of dialogue from Paulo Freire and using cogenerative dialogue, as proposed by Tobin and Roth (2004), we analyze the dialogue between two teachers-researchers, talking about their trajectories in their respective positions. From this dialogue, we engage in

theorizing from Paulo Freire's and Gloria Anzaldua's thought and from science education research to reflect upon the role of teachers-researchers in crossing and disrupting borders in terms of advancing challenges and opportunities concerning institutions, identities, and the relationship between research-practice. In our results, we identify and discuss: the structural conditions to perform this role, such as career plan and institutional support; ambiguities and struggles regarding teachers-researchers' identities when crossing borders; some dilemmas and impacts of this dual role in the type of research that is performed by teachers-researchers. In lieu of a conclusion, those aspects are discussed in dialogue with the field of science education, presenting ways to further close the gap between research and practice through the teachers-researchers' actions.

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582 Virtual-Natural Interface: Teachers Work as a Epistemic Brokering Activity

Eun-Ji Amy Kim

Griffith University, Brisbane, Australia

Abstract

Over the years, interdisciplinary and intercultural learning approaches have been advocated by many national and state curricula around the globe. In turn, these initiatives created diverse 'cultural interfaces' for teachers to navigate. The global community is moving towards virtual experience as the main tenet of human interaction in the era of the fourth industrial revolution. This paper explores this new type of curricular interface (Virtual Reality-Physical Reality interface) created by virtual reality (VR) learning platforms such as the Metaverse. Specifically in this article, we reflect on the cultural interface between Indigenous knowledge and Western Science. Through the reflections on the lessons learned from this Indigenous Knowledges-Western Modern Science cultural interface, the author suggests the theoretical and practical consideration for teachers' curricula work as an epistemic brokering activity in the curricula interface.

Parallel Session - 6.18 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

55 SIG 2: Added Insights Through Video Based Analysis? What Different Frameworks Can Reveal.

Chair

Kathrin Otrel-Cass

Discussant

Jaume Ametller Leal

Abstract

Methods for analyzing classroom interactions in science education through video-based data have improved significantly over the past few years (Martin & Siry, 2012). To some extent this is the case since video offers unprecedented possibilities to research various aspects of classroom cultures, practices and activities, utilizing different forms and formats of analysis, presentation and publications. Broadly speaking video-based research in science education draws on the insights from fields of (science) education, sociology, social anthropology, communication and linguistics. And, as it is the case in other fields of education research, different theoretical frameworks allow researchers to foreground some aspects over others through their analysis, in order to problematize and propose ways forward. One of the advantages of video data is that it provides more information for analysis than examining talk only, it captures the complexity and multimodality of classroom teaching (Flewitt, 2006). This opportunity is also a challenge since it complicates the systematic inspection of educational practices (Bezemer & Mavers, 2011). In this invited symposium organized by SIG 2, we present examples of video-based research in science education that detail the advantages and challenges of theoretical frameworks of analysis that go beyond talk. The presentations detail the key corner stones of their theoretical frameworks and how they can be applied to the analysis of video data. The symposium focuses on the reasons why it is relevant and necessary to conduct video based research and the kind of productive opportunities for teaching and learning in science education it offers.

662 Modes of Video Analysis to Support Preservice Teacher Education in Austria

Kathrin Otrel-Cass

University of Graz, Graz, Austria

Abstract

Making sense of classroom practices as a preservice teacher can be overwhelming. Unless direct classroom observations are made with specific questions in mind (e.g., by using focus questions) direct observations can be messy (Ball, 2000). It is hoped that through the exposure to video recorded examples preservice teachers have additional learning opportunities where they get a chance to connect theory with practice. Although guidance to conduct the analysis of video material is most times provided, this is usually done by specifying single focus questions only. The other challenge is that there is often a focus on spoken words, at least in the first instance. A general challenge is that the analysis of video in preservice teaching is often descriptive, based on anecdotal knowledge and "gut instinct". This paper presents a further development to systematic video analysis in teacher education. It includes Kristensen 's (2018) approach to foreground the analysis of embodied practices and utilises Seidel, Blomberg and Renkl's (2013) suggestion to introduce students first to theoretical rules and then to view video examples. After a discussion on theory, preservice students were asked to start their analysis by watching video first without sound and identify 1) anything they found interesting about the students, 2) the teacher 3) and space and materials. In the next round students were asked to read the transcript (including notations of non-verbal aspects) with the same focus reflections (1-3). Finally, students were asked to watch the video with their notes and the transcript and repeat their observation once more, then share their reflections. I present examples of those reflections that were collected as part of a preservice teaching activity focusing on selected teaching methods.

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675 Degrees of Conceptualization of Students According to Their Performance and Sociocultural Levels When Carrying Out Scientific Task: Contribution of the Analysis of Gestures

Mylène Duclos, Florence Le Hebel, Andrée Tiberghien

ICAR, LLE, CNRS, ENS Lyon, University of Lyon, Lyon, France

Abstract

This presentation is situated in a larger study focused on the influences of the students' sociocultural level and performance level on how they perform science tasks. This study aimed at identifying task characteristics that lead to differences in performance between students of different economic social and cultural status (ESCS) and performance levels. The chosen approach is quantitative and qualitative; the tasks are the 183 PISA 2015 items. The qualitative analysis is based on video data of pairs of students (grouped with similar performance and ESCS) carryout out PISA tasks. To better understand how students perform the task and their strategies for doing so, the theoretical framework includes a model of response (Pollitt & Ahmed, 2001) that distinguishes several phases with possible back and forth, notably the reading of the question and the interpretation of the situation presented with the question. The need to analyse the different strategies of students led the researcher to include nonverbal behaviours recognized as playing an important role in scientific explanation since it involves a

variety of semiotic modes (speech, numerical, graphical, and gestural). The gestures analysis is based on McNeill theory (2005). In this communication, a case study of the analyses of pairs of students according to their performance and sociocultural levels will be presented. This analysis will illustrate the differences in the types of gestures according to the students, in particular the deictic and metaphoric gestures during the phases of carrying out the task. Our data show that students with a high cultural and performance level use metaphoric gestures more frequently, whereas students with low cultural and performance levels use most of the time only deictic gestures; this illustrates different degrees of conceptualization.

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677 Video-Based Analysis of Inquiry-Based Instruction in Classroom Practice; Why It Matters, What Makes It Challenging, and Ideas on How to Move Forward

Andreas Vorholzer[1], Verena Petermann[2], Joé Weber[3], Rüdiger Tiemann[3], Annette Upmeier zu Belzen[3]

[1]Technical University Munich, School of Social Sciences and Technology, Munich, Germany. [2]Justus Liebig University Giessen, Giessen, Germany. [3]Humboldt-Universität zu Berlin, Berlin, Germany

Abstract

In typical science classrooms, students frequently engage in inquiry-related activities such as formulating questions, conducting experiments, and analysing data. Corresponding instructional approaches are often referred to as inquiry-based instruction (IBI) and assumed to contribute to a wide range of objectives of science education, including fostering students' content knowledge, procedural knowledge or epistemic knowledge. Evidence suggests that neither is IBI per se effective nor are all potential goals achieved automatically through IBI, but its effect depends on how inquiry-related activities are implemented in science lessons. Therefore, insights into what inquiry-based science lessons typically look like and how IBI is implemented in classroom practice is an interesting and relevant subject for video-based research. This contribution will present a recently published study that analysed $N = 16$ inquiry-based biology and chemistry lessons from German upper-secondary classrooms. The analysis focused on how inquiry activities are combined with elements of explicit instruction on procedural and epistemic knowledge. We will utilise the example of this study to illustrate the insights we as a community may gain from video-based analysis of IBI as well as the potential theoretical and methodological challenges such studies may face. These challenges comprise, for instance, the ambiguity of having scientific inquiry as both a method and a goal of instruction or the impact of the variety of objectives teachers may try to achieve using IBI. We will discuss the impact of these challenges on the validity of the results and outline methodological recommendations as well as interesting topics for future video-based studies on the use of IBI in classrooms.

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671 Variety of Semiotic Modes in Interactions Between Students in Relation to the Knowledge at Stake

David Cross[1], Andree Tiberghien[2]

[1]LIRDEF, Université de Montpellier, Montpellier, France. [2]ICAR CNRS ENS-Lyon, Lyon, France

Abstract

This communication deals with an aspect of science classroom practices, the way students and teacher use various semiotic modes (speech, gestures, gaze, and proxemics) to contribute to the evolution of classroom knowledge. The theoretical framework combines the social semiotic theory of multimodality (Jewitt 2008; Kress 2010) and the theory of joint action in didactics (Sensevy 2011) following Moro et al. (2020). In the social semiotic approach, it is considered that people express meaning through their selection of the semiotic resources that are available to them at a particular moment. This is close to our didactic approach based on the joint action theory. In this theory, with a pragmatic orientation, teaching and learning are considered as two joint actions. This double approach leads us to analyze the combinations of semiotic modes used by the teacher and the students to communicate, and in particular to contribute to the understanding and development of knowledge and thus assume responsibility for their contribution. Our study investigates the combinations of different semiotic modes used by students working in small group in order to assume responsibility of the development of knowledge to carry out an activity proposed by the teacher.We propose a case study of two students working in group during the first session of a teaching sequence on periodic phenomena at grade 10 in physics. At the request of the teacher, students collaborate but their interactions involve aspects of knowledge like the denomination of a movement back and forth and not the meaning of this movement in terms of regularity, period and/or frequency. This avoidance of discussing the meaning of the situation to be studied, which is the result of the joint actions of the students, is manifested by various semiotic modes (positions of bodies, gazes, gestures, words) that we will present and discuss.

Parallel Session - 6.19 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

Phenomenography in Physics Education Research for Understanding Students' Difficulties When Learning Physics Topics

Chair

Esmeralda Campos

Discussant

Jenaro Guisasola

Abstract

Physics education research is a branch of science education that broadly focuses on the way that students learn different topics of physics. While quantitative approaches have paved the way for physics education research, qualitative methods such as phenomenography have been growing in recent years for various reasons, such as the in-depth results that can be derived about students' understanding of several physics concepts. This symposium aims to gather the experience of different teams that have performed phenomenography in physics education research. The presentations that form this symposium have the phenomenographic approach as a common denominator to explore students' understanding of various topics of physics education. The collection of works is valuable for the science teaching and learning community because these examples show the versatility of phenomenography to achieve a broad range of objectives. In the following lines, we provide a summary of each contribution highlighting its use of phenomenography. The first contribution presents research about students' understanding of physical concepts related to the greenhouse effect. In this work, the authors performed longitudinal studies with students that range from high school to advanced undergraduate university courses. They present results of student understanding through the different stages for three different concepts related to the greenhouse effect: energy exchange, temperature, and the basic mechanism of the greenhouse effect. In this case, phenomenography allowed the analysis of students' responses to the same questions across different academic levels. The second contribution presents research about students' understanding of a multivariable calculus concept in a math and physics context, namely, the gradient and the Laplacian. In this work, the authors analyse and compare advanced university students' responses to an open-ended questionnaire across contexts (math and physics) and representational use (semantic synonyms, graphics and vectors). Phenomenographic analysis allowed the authors to make comparisons across the context through the classification of the categories into themes that describe the representational use. In this case, the comparison between contexts is direct because the questions of the study are isomorphic. The third contribution presents research about students' understanding of several key concepts of electricity and magnetism. In this work, the authors present an overview of a series of studies where they have analysed and compared introductory university students' conceptual difficulties in two physical contexts: electricity and magnetism. The key concepts that they studied are electric and magnetic fields, interactions and the application of the superposition principle. The phenomenographic analysis allowed the authors to compare across contexts. In this case, the comparison between contexts is indirect because the problems are not isomorphic (the electric and magnetic field and forces are different in nature, so the problems have different solutions). The fourth contribution presents research about university students' understanding of rigid body dynamic. In this work, the authors used the phenomenographic analysis to compare with the epistemic knowledge and how they progress after instruction. Through this process, the authors could identify the learning demand for each of the key concepts. This is the first step towards creating a Teaching-Learning Sequence, after identifying students' learning demand through phenomenography.

668 Phenomenographyc Analisys of Students Understanding of Rigid Body Dynamic

Paulo Sarriugarte[1], Jaume Ametller[2], Kristina Zuza[3]

[1]Applied Physics Department and DoPER, UPV/EHU, Bilbao, Basque Country, Spain. [2]Department of Specific Didactics, University of Girona, Girona, Catalonia, Spain. [3]Applied Physics Department and DoPER, UPV/EHU, Donostia-San Sebastian, Basque Country, Spain

Abstract

Here we present how we analyze the difficulties encountered by first-year university students in understanding the moment of inertia in phenomena of rotation of a rigid body about a fixed axis. We first designed an open-ended questionnaire following an epistemological analysis in order to raise the key concepts needed for a proper understanding of the moment of inertia of a rigid body. The questionnaire was taken by first year students in a calculus-based introductory physics course and we analyzed their answers with a phenomenographic analysis, i.e. classifying the answers into pre-defined categories. The categorization reveals how far the students stand from the epistemic knowledge we expect on the key concepts linked to each question. Obtained results let us define the learning demands corresponding to each key concept which paths the way to design an improved Teaching Learning Sequence (TLS) to be implemented in lectures.

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659 Students' Understanding of Gradient and Laplacian in Math and Physics Contexts

Maria Al Dehaybes[1], Johan Deprez[1], Paul van Kampen[2], Mieke De Cock[1]

[1]KU Leuven, Leuven, Belgium. [2]Dublin City University, Dublin, Ireland

Abstract

In this study, we investigate undergraduate students' understanding of two multivariable calculus concepts, the gradient and the Laplacian, using open ended paper-and-pencil tests. We study students' reasoning in two contexts: math and physics, and in different graphical representations of multivariable functions: 3D graphs and contour plots for the gradient, and 3D graphs and vector plots for the Laplacian. Findings reveal that students have a context-specific preference for representing their answers and demonstrate varying reasoning competencies for the same concept in different answer representations.

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699 Student Understanding of Physical Concepts Related to the Greenhouse Effect: A phenomenographic Analysis

Massimiliano Malgieri[1], Pasquale Onorato[2], Stefano Toffaletti[2], Anna De Ambrosis[1]

[1]Department of Physics, University of Pavia, Pavia, Italy. [2]Department of Physics, University of Trento, Povo (TN), Italy

Abstract

This work summarizes several years of research on teaching the physical basis of the greenhouse effect at different years of instruction. A phenomenographic analysis is performed on cumulative pre-test data from different year samples, divided by level of instruction. The analysis revolves on key questions concerning a) radiative exchanges in vacuum and radiative equilibrium; b) behaviour of bodies with different surface reflectivity exposed to sunlight; c) the basic physical mechanism of the greenhouse effect. It is found that one the main alternative conceptions which hamper the construction of consistent mental models of the greenhouse effect is remarkably resistant to instruction.

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832 Phenomenographic Analysis of Student Understanding of Parallel Concepts of Electricity and Magnetism

Esmeralda Campos[1], Eder Hernandez[1], Pablo Barniol[1], Genaro Zavala[1,2]

[1]Tecnologico de Monterrey, Monterrey, Mexico. [2]Universidad Andres Bello, Santiago, Chile

Abstract

Identifying students' difficulties in understanding physical concepts of electromagnetism, such as fields, force and the superposition principle, is important for developing educational strategies that promote an expert-like understanding of electromagnetic phenomena. We have conducted a series of studies that aim to analyse and compare students' understanding of electric and magnetic forces and fields, and the superposition principle. This contribution presents how we have used phenomenography to analyse and compare students' difficulties in the context of electricity and magnetism. We present an overview of the difficulties that we have found regarding students' understanding of (1) electric and magnetic fields and the principle of superposition, (2) electric charges in rest and in motion in electric and magnetic-field regions, and (3) electric and magnetic interactions.

Parallel Session - 6.20 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

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59 Using DBR to Make TLS (Re)design Explicit: Theory, Evaluation and Teacher Training

Chair

Kristina Zuza

Discussant

Italo Testa

Abstract

This set of paper bring together different perspectives on research around Teaching Learning Sequence design. The four contributions have different aims present, partly, different theoretical frameworks and, yet, the use of Design-Based Research methodology provides the elements to engage in productive dialogue and criticism. The explicit reference to theoretical frameworks and their connection to the design also pushes all the participants to reflect on the basis of their work clarifying their proposals and moving the frameworks they use further, two elements required to strengthen science education research as a whole. The first paper presents a theoretical discussion on how to operationalize theory and empirical results into design decisions. While this is a topic that can be found across the whole symposium, this paper puts forward a framework that uses seven dimension and three levels of concreteness with the aims of covering all the broad consensus in science education research and a process of moving from the most general ideas to the most concrete guidance in the design process. This proposal is exemplified with a TLS on the Sun-Earth system that is design bringing together explicitly three cycles: inquiry, modelisation and emotions. The second paper is also interested in the connection between theoretical assumptions and design. While the first paper look at dimensions that went beyond the conceptual content to design a TLS that makes use of present knowledge in the field in the different dimensions that shape the teaching and learning process, the second paper addresses some of the changes in the scope of science education itself. To explicitly address this aim the authors bring new theoretical perspectives into science education and rethink more traditional ones; reconsidering the epistemology of physics to design TLS proposals that resonate with new perspectives on social processes reshaping students' experience. This proposal, therefore, showcases how DBR applied to TLS design can foster theoretical discussion that has practical implications through the definition of intermediate constructs, such as the design principles. The last two papers put the focus on the teachers. The third paper studies how participating in a DBR process to design and implement TLSs can be seen as a teacher training activity. The connection between designing or implementing TLSs has long been argued but this paper presents an empirical research with concrete results. As a whole, the results support that this participation has improved the teachers' PCK but also some aspects of teaching known to be difficult to develop through short interventions such as dialogic teaching. Overall, this contribution is firmly pointing at the fact that TLS design cannot just influence "immediate practice" but can also build potential for improving future practice by developing transferable skills. The last paper also deals with teachers involved in DBR TLS processes. In this case, by looking at how teachers can have a tangible input into the development of TLSs by playing a role specific to teachers and well differentiated from that of researchers. This is significant because it suggests ways of fostering teachers' collaborations that could be integrated into their school practice. The other focus of this paper is the final stage of the DBR process, the redesigning of the TLS proposal. This is a fundamental part of the process if TLS design is to grow as a research programme but one that has been less explored, in theoretical proposals, than the first design of the TLS. The paper reflects on how evaluation of the implementation must take into account different dimensions of the quality of the TLS and on how they can be brought together to make explicit the movements from evaluation results to redesigning choices.

724 Decisions for Designing Teaching-Learning Sequences: Dimensions and Levels of Concrects in TLS Sun-Earth.

M Rut Jimenez-Liso, Rafael López-Gay Lucio-Villegas, Maria Martínez-Chico, Manuela Gonzalez-Herrera

University Of Almeria, Almeria, Spain

Abstract

The operationalisation of the design of Teaching-Learning Sequences has been an objective of Science Education for years. In this theoretical paper we reflect on the difficulties due to the lack of concreteness of converting theoretical references and research results into TLS design decisions. We propose three levels of concreteness (principles, elements and tools) for seven dimensions (epistemological, psychological, instructional, contextual, conceptual, affective-emotional and ideological) applied to a TLS on Sun-Earth and a preview of implications for teaching design in PreService Science Teachers Training.

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722 DBR Based Design of a TLS on Dynamics for High School: The Role of Teachers in the Re-Design

Leire Olazabal[1,2], Kristina Zuza[2], Paulo Sarriugarte[3], Jaume Ametller[4], Jenaro Guisasola[5]

[1]Orixe BHI, Tolosa, Basque Country, Spain. [2]Applied Physics Department and DoPER, UPV/EHU, Donostia, Basque Country, Spain. [3]Applied Physics Department and DoPER, UPV/EHU, Bilbo, Basque Country, Spain. [4]Universitat de Girona, Girona, Catalonia, Spain. [5]College of dual engineering. Insitute of Machine tools campus (IMH) and DoPER, Donostia, Basque Country, Spain

Abstract

This paper describes the use of Design Based Research (DBR) methodology to design, implement, evaluate and redesign a Teaching Learning Sequence (TLS) on Newton's Laws for secondary school. The focus in this work is the active role of teachers in all the stages of the process and on the use of evaluation data to redesign the TLS.

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809 Designing Epistemological Curricula to Align Physics Teaching with the Society of Acceleration and Uncertainty

Olivia Levrini, Paola Fantini

Alma Mater Studiorum - University of Bologna, Bologna, Italy

Abstract

In the contribution, we present a design-based research process that progressively led us to build teaching modules aimed to align physics teaching with the society of acceleration and

uncertainty. Through the process, the epistemological richness of physics has been exploited to regenerate disciplinary knowledge and make physics a locus to develop both personal identities, and competences needed to navigate current society. The design-based approach allowed us to keep track of our research progression and consciously combine different frameworks from science education and the learning sciences, including the model of educational reconstruction, the coordination class theory for conceptual change, the meta-theory of boundary for interdisciplinarity. In the presentation, after describing the process, we focus on the modules of thermodynamics and climate change to discuss our design principles. Specifically, we will argue how these principles represented our compass to make the epistemology of physics resonate with students' personal processes of sense-making and ground, in the disciplines, the development of sustainability competences like embracing complexity, envisioning futures and enacting creative thinking.

949 Providing an Arena for Professional Development for Physics Teachers Through Design-Based Research

Thomas Frågåt[1,2], Maria Vetleseter Bøe[2], Carl Angell[2]

[1]Inland Norway University of Applied Sciences, Hamar, Norway. [2]University of Oslo, Oslo, Norway

Abstract

In this qualitative study, we involved physics teachers in a design-based research (DBR) project. The teachers were involved in developing and testing learning resources in modern physics and they attended seminars and workshops where they collaborated with physics educational researchers, disciplinary experts, and peers. Through a thematic analysis using pedagogical content knowledge (PCK) as analytical framework, we found that the teachers had gained enhanced PCK, content knowledge, and their self-confidence had increased as a result of the collaboration. Based on these findings, we suggest that involving teachers in DBR projects could be an arena for professional development meeting the calls for a strengthened research-informed teaching culture.

Parallel Session - 6.21 (Symposium)

09:00 - 11:00 Thursday, 31st August, 2023

55 SIG 2: Added Insights Through Video Based Analysis? What Different Frameworks Can Reveal.

Chair

Kathrin Otrel-Cass

Discussant

Jaume Ametller Leal

Abstract

Methods for analyzing classroom interactions in science education through video-based data have improved significantly over the past few years (Martin & Siry, 2012). To some extent this is the case since video offers unprecedented possibilities to research various aspects of classroom cultures, practices and activities, utilizing different forms and formats of analysis, presentation and publications. Broadly speaking video-based research in science education draws on the insights from fields of (science) education, sociology, social anthropology, communication and linguistics. And, as it is the case in other fields of education research, different theoretical frameworks allow researchers to foreground some aspects over others through their analysis, in order to problematize and propose ways forward. One of the advantages of video data is that it provides more information for analysis than examining talk only, it captures the complexity and multimodality of classroom teaching (Flewitt, 2006). This opportunity is also a challenge since it complicates the systematic inspection of educational practices (Bezemer & Mavers, 2011). In this invited symposium organized by SIG 2, we present examples of video-based research in science education that detail the advantages and challenges of theoretical frameworks of analysis that go beyond talk. The presentations detail the key corner stones of their theoretical frameworks and how they can be applied to the analysis of video data. The symposium focuses on the reasons why it is relevant and necessary to conduct video based research and the kind of productive opportunities for teaching and learning in science education it offers.

662 Modes of Video Analysis to Support Preservice Teacher Education in Austria

Kathrin Otrel-Cass

University of Graz, Graz, Austria

Abstract

Making sense of classroom practices as a preservice teacher can be overwhelming. Unless direct classroom observations are made with specific questions in mind (e.g., by using focus questions) direct observations can be messy (Ball, 2000). It is hoped that through the exposure to video recorded examples preservice teachers have additional learning opportunities where they get a chance to connect theory with practice. Although guidance to conduct the analysis of video material is most times provided, this is usually done by specifying single focus questions only. The other challenge is that there is often a focus on spoken words, at least in the first instance. A general challenge is that the analysis of video in preservice teaching is often descriptive, based on anecdotal knowledge and "gut instinct". This paper presents a further development to systematic video analysis in teacher education. It includes Kristensen 's (2018) approach to foreground the analysis of embodied practices and utilises Seidel, Blomberg and Renkl's (2013) suggestion to introduce students first to theoretical rules and then to view video examples. After a discussion on theory, preservice students were asked to start their analysis by watching video first without sound and identify 1) anything they found interesting about the students, 2) the teacher 3) and space and materials. In the next round students were asked to read the transcript (including notations of non-verbal aspects) with the same focus reflections (1-3). Finally, students were asked to watch the video with their notes and the transcript and repeat their observation once more, then share their reflections. I present examples of those reflections that were collected as part of a preservice teaching activity focusing on selected teaching methods.

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675 Degrees of Conceptualization of Students According to Their Performance and Sociocultural Levels When Carrying Out Scientific Task: Contribution of the Analysis of Gestures

Mylène Duclos, Florence Le Hebel, Andrée Tiberghien

ICAR, LLE, CNRS, ENS Lyon, University of Lyon, Lyon, France

Abstract

This presentation is situated in a larger study focused on the influences of the students' sociocultural level and performance level on how they perform science tasks. This study aimed at identifying task characteristics that lead to differences in performance between students of different economic social and cultural status (ESCS) and performance levels. The chosen approach is quantitative and qualitative; the tasks are the 183 PISA 2015 items. The qualitative analysis is based on video data of pairs of students (grouped with similar performance and ESCS) carryout out PISA tasks. To better understand how students perform the task and their strategies for doing so, the theoretical framework includes a model of response (Pollitt & Ahmed, 2001) that distinguishes several phases with possible back and forth, notably the reading of the question and the interpretation of the situation presented with the question. The need to analyse the different strategies of students led the researcher to include nonverbal behaviours recognized as playing an important role in scientific explanation since it involves a

variety of semiotic modes (speech, numerical, graphical, and gestural). The gestures analysis is based on McNeill theory (2005). In this communication, a case study of the analyses of pairs of students according to their performance and sociocultural levels will be presented. This analysis will illustrate the differences in the types of gestures according to the students, in particular the deictic and metaphoric gestures during the phases of carrying out the task. Our data show that students with a high cultural and performance level use metaphoric gestures more frequently, whereas students with low cultural and performance levels use most of the time only deictic gestures; this illustrates different degrees of conceptualization.

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677 Video-Based Analysis of Inquiry-Based Instruction in Classroom Practice; Why It Matters, What Makes It Challenging, and Ideas on How to Move Forward

Andreas Vorholzer[1], Verena Petermann[2], Joé Weber[3], Rüdiger Tiemann[3], Annette Upmeier zu Belzen[3]

[1]Technical University Munich, School of Social Sciences and Technology, Munich, Germany. [2]Justus Liebig University Giessen, Giessen, Germany. [3]Humboldt-Universität zu Berlin, Berlin, Germany

Abstract

In typical science classrooms, students frequently engage in inquiry-related activities such as formulating questions, conducting experiments, and analysing data. Corresponding instructional approaches are often referred to as inquiry-based instruction (IBI) and assumed to contribute to a wide range of objectives of science education, including fostering students' content knowledge, procedural knowledge or epistemic knowledge. Evidence suggests that neither is IBI per se effective nor are all potential goals achieved automatically through IBI, but its effect depends on how inquiry-related activities are implemented in science lessons. Therefore, insights into what inquiry-based science lessons typically look like and how IBI is implemented in classroom practice is an interesting and relevant subject for video-based research. This contribution will present a recently published study that analysed $N = 16$ inquiry-based biology and chemistry lessons from German upper-secondary classrooms. The analysis focused on how inquiry activities are combined with elements of explicit instruction on procedural and epistemic knowledge. We will utilise the example of this study to illustrate the insights we as a community may gain from video-based analysis of IBI as well as the potential theoretical and methodological challenges such studies may face. These challenges comprise, for instance, the ambiguity of having scientific inquiry as both a method and a goal of instruction or the impact of the variety of objectives teachers may try to achieve using IBI. We will discuss the impact of these challenges on the validity of the results and outline methodological recommendations as well as interesting topics for future video-based studies on the use of IBI in classrooms.

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671 Variety of Semiotic Modes in Interactions Between Students in Relation to the Knowledge at Stake

David Cross[1], Andree Tiberghien[2]

[1]LIRDEF, Université de Montpellier, Montpellier, France. [2]ICAR CNRS ENS-Lyon, Lyon, France

Abstract

This communication deals with an aspect of science classroom practices, the way students and teacher use various semiotic modes (speech, gestures, gaze, and proxemics) to contribute to the evolution of classroom knowledge. The theoretical framework combines the social semiotic theory of multimodality (Jewitt 2008; Kress 2010) and the theory of joint action in didactics (Sensevy 2011) following Moro et al. (2020). In the social semiotic approach, it is considered that people express meaning through their selection of the semiotic resources that are available to them at a particular moment. This is close to our didactic approach based on the joint action theory. In this theory, with a pragmatic orientation, teaching and learning are considered as two joint actions. This double approach leads us to analyze the combinations of semiotic modes used by the teacher and the students to communicate, and in particular to contribute to the understanding and development of knowledge and thus assume responsibility for their contribution. Our study investigates the combinations of different semiotic modes used by students working in small group in order to assume responsibility of the development of knowledge to carry out an activity proposed by the teacher.We propose a case study of two students working in group during the first session of a teaching sequence on periodic phenomena at grade 10 in physics. At the request of the teacher, students collaborate but their interactions involve aspects of knowledge like the denomination of a movement back and forth and not the meaning of this movement in terms of regularity, period and/or frequency. This avoidance of discussing the meaning of the situation to be studied, which is the result of the joint actions of the students, is manifested by various semiotic modes (positions of bodies, gazes, gestures, words) that we will present and discuss.

Parallel Session - 6.21 (WORKSHOP)

09:00 - 11:00 Thursday, 31st August, 2023

1126 Expanding Notions of Cultural Heritage in Science Education: Examples From Low-Resource Settings in Ghana and the USA

Josephine Godwyll[1,2], Charles Ofori[3], Priscilla Jeffery[4,5], Connie Chow[6]

[1]University of Alberta, Edmonton, Alberta, Canada. [2]Young at Heart Ghana, Kumasi, Ghana. [3]DEXT Technologies, Kumasi, Ghana. [4]Rural Education Advocacy Project, Nsawam, Ghana. [5]Rural Education Advocacy Project, Bantam, CT, USA. [6]University of Kansas, Lawrence, KS, USA

Abstract

We use examples of innovative practices and technologies from four different programs in Ghana and the USA to explore and interrogate the conference theme, Connecting Science Education with Cultural Heritage. We introduce participants to tools and practices, designed for low-resource contexts in Ghana and the USA, that can be incorporated into the global classroom, including traditionally under-invested schools in developed world settings. This is valuable given the increasing number of diasporic and immigrant populations, as well as the need for recognition of and credit to native peoples and their contributions in all countries, and responsibility of cultural literacy for science educators. Using a rotating station format, participants will explore 1) *Ananse the Teacher* app, the first African folklore-based STE(A)M mobile app and game; 2) table top science sets that address learning standards in Ghana; 3) an art, history and science curriculum about the Abenaki; and 4) *Solve for Ghana!* design challenges that encourage the incorporation of community funds of knowledge and scientific thinking. These examples contextualize related scientific concepts through the lens of indigenous and/or local cultural practices, and incorporate storytelling, as a vehicle for context-based learning and problem solving. We provide examples of learner-initiated inventions to show that when cultural relevance and frugal innovation are principle, process and product of these learning experiences, student interest and confidence in science as well as their self-efficacy increase. We hope the workshop and discussions will liberate us from the limitations of curriculum standards, lead to greater understanding of the value of including an expansive view of cultural heritage, avoid tokenization, prompt intellectual connections and inspire collaborative projects in curriculum and technology exchange, design and development.

Parallel Session - 6.22 (WORKSHOP)

09:00 - 11:00 Thursday, 31st August, 2023

1041 Befriending Desires for Justice-Oriented STEM Teaching and Research

Sarah El Halwany[1], Rachael Edino[1], Sophia Marlow[1], Nadia Qureshi[2], Kristen Schaffer[3], Kristal Turner[1], Jennifer Adams[1]

[1]University of Calgary, Calgary, Canada. [2]University of Toronto, Toronto, Canada. [3]Mount Royal University, Calgary, Canada

Abstract

This workshop is a methodological and pedagogical experiment in centering desire-based design for creatively reimagining ways of knowing, being and relating in science education. We stage opportunities for participants to become attuned to their desires in teaching and research practices, foreground their subjectivities while generating pedagogical and methodological considerations for social justice approaches in STEM/science education.

Parallel Session - 6.23 (WORKSHOP)

09:00 - 11:00 Thursday, 31st August, 2023

1258 Designing an Educational Escape Room: Evidence-Based Guidelines and Practical Advice

Georgios Villias

University of Cambridge, Cambridge, United Kingdom

Abstract

Educational escape rooms (EERs) have been gaining momentum within the educational community since their first appearance a few years ago. Appearing in various forms (physical escape rooms, escape boxes, digital escape rooms), they managed to make it through the COVID-19 pandemic. Several different frameworks have been proposed for facilitating practitioners to create their own EER activities. This workshop, intents to familiarise its participants to the conceptual and design framework of an educational escape room as well as to present them examples of EER activities and different types of puzzles that have been thoroughly studied. It will also offer them the opportunity to actively engage in a biology-related EER activity, and brainstorm on the development of their very own educational escape room.

Parallel Session - 6.24 (WORKSHOP)

09:00 - 11:00 Thursday, 31st August, 2023

835 "The Bombastics": A Series of Co-Created Scientific Comics for Secondary School

Víctor López-Simó[1], Laurence Bordenave[2], Zofia Chyleńska[3], Cláudia Faria[4], Valentin Maron[5], Bianor Valente[6], Digna Couso Lagarón[1]

[1]UAB, Barcelona, Catalunya, Spain. [2]Stimuli association, París, France. [3]Department of Nature Education and Conservation, Adam Mickiewicz University, Poznan, Poland. [4]Instituto de Educação da Universidade de Lisboa, Lisboa, Portugal. [5]Université Toulouse Jean Jaurès, Laboratoire EFTS (Education, Formation, Travail, Savoirs), Tolouse, France. [6]Escola superior de educação de Lisboa, Instituto Politécnico de lisboa, Lisboa, Portugal

Abstract

"The Bombastics" consist of a series of eight educational scientific webcomics in which four fictional secondary school students and members of drama group experience a set of debates on stage and in every-day life adventures related with different scientific topics, such as biodiversity, energy, or climate physics. Each episode includes a set of associated teaching materials that will be translated to 78 different languages and freely available to the European Science Education community. The design of this series of webcomics follows a co-creative process that involves teachers, researchers, artists, and other stakeholders, under the umbrella of the Erasmus Project "ECOSCOMICS": European Co-Construction of Science WebComics. In the workshop participants will have the opportunity to read the first four episodes, to test the associated teaching resources and to participate in the conceptualization of the upcoming episodes.

Parallel Session - 6.25 (WORKSHOP)

09:00 - 11:00 Thursday, 31st August, 2023

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525 Integration of Artificial Intelligence Tools in Chemistry Education –Trust, Principles and Future Directions

Yael Feldman-Maggor[1], Tanya Nazaretsky[1], Carmel Kent[2], Mutlu Cukurova[3], Giora Alexandron[1]

[1]The Weizmann Institute of Science, Rehovot, Israel. [2]The Open University, Milton Keynes, United Kingdom. [3]UCL, London, United Kingdom

Abstract

Artificial Intelligence(AI)-based suggestions are becoming an integral part of our daily lives. These technological advancements have also entered the science education sphere. Indeed, with the widespread use of online and blended learning environments, there are increasing opportunities for integrating AI into science education. As this development unfolds and educators could potentially become more reliant on AI technologies, how can they ensure they receive trustworthy teaching recommendations? While many studies focus on data collection and algorithm development, scholars have yet to examine the end-user interpretation of AI tools. Yet, it is the educators who decide whether to accept or reject AI-based advice. Our study addresses this gap by asking how end-users, particularly teachers, interpret algorithmic-generated recommendations and investigate ways to increase their trust in AI. In this workshop, we discuss our research which examines whether science teachers' trust in AI can be improved when the process behind AI-generated recommendations is transparent, and AI models are explained to teachers in layman's terms. This workshop will feature a hands-on demonstration of using an AI-for-Teacher technology that supports personalized instruction in science education. This tool combines an AI algorithm, student response data, and expert knowledge to perform a multidimensional analysis of student responses. It then divides students into

groups with similar knowledge profiles. Results presented in an interactive dashboard enable teachers to examine each group's performance and assign learning activities adapted to the needs of student groups based on their strengths and weaknesses. The tool was conceptualized in a co-design process that involved learning analytics researchers, science educators, teachers, and instructional designers. In this workshop, participants will experience the AI tool developed in our group. Additionally, we will explore and discuss the topic of trust and the potential use of AI group-based personalization tools in the context of chemistry education.

Parallel Session - 6.26 (WORKSHOP)

09:00 - 11:00 Thursday, 31st August, 2023

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873 Light and Color in the Chemistry Classroom – Interactive Visualizations as OER

Amina Zerouali, Bernhard Werner, Doris Lewalter, Jenna Koenen

Technical University of Munich, Munich, Germany

Abstract

Students tend to develop their own concepts to interpret everyday phenomena. These concepts often differ decisively from the proper scientific constructs/contents. Therefore, it is essential to consider these alternative conceptions for the development of learning materials, as they considerably influence the learning process. Interactive visualizations provide an effective method to address and revise these alternative concepts. For this reason, seven visualizations for chemistry lessons in the classroom have been developed to address the topic of light and color perception for organic dyes. They focus on the understanding and interpretation of everyday phenomena, students are frequently confronted with. Meaning they can support the development of student's own ideas and concepts about scientific issues. In this ICT demonstration, the seven new interactive visualizations on the topic of light and color are presented, as well as a possible implementation in the classroom. Participants will be able to test the visualizations independently during this session. Furthermore, we will provide a set of supporting materials including an example of a possible implementation in the classroom. Participants are afterwards invited to reflect upon and discuss the ways of using the visualizations in the learning process.

Parallel Session - 6.26 (WORKSHOP)

09:00 - 11:00 Thursday, 31st August, 2023

982 Labs4Future – How Climate Change Knowledge Can Be Linked to Effective Climate Action

Jonathan Grothaus, Markus Elsholz, Thomas Trefzger

Universität Würzburg, Würzburg, Germany

Abstract

This workshop presents the central elements of and thoughts behind the two-day student laboratory Labs4Future. This student laboratory (for 14–15-year-old high school students) tries to manage the linking of learned knowledge about climate change with evoking effective individual and societal action. Based on a newly developed theoretical framework Lessons4Future, which integrates environmental psychology, sociology and science education, the workshop showcases how we try to transfer the theory into experiments and activities. Hands-on elements include the so-called Carbon Credits, an area visualization of daily personal and societal emissions, that address effectiveness knowledge and perceived behavioural control. Personal and moral norms and system thinking are being addressed in a Mystery about the complicated attribution of guilt for climate change related deaths. And climate anxiety or fear are being resolved in a utopia-thinking method, that also tries to break up the unquestioned habits of society and conceptualize other ways of living a happy and sustainable live. The student laboratory has been tested and empirically evaluated in two iterations of an ongoing design-based research project with about 300 high school students. Using a mixed-methods research design, we quantitatively evaluated climate change knowledge, climate anxiety, perceived behavioural control, but also self-reported behaviour in a pre-post-follow-up design. Additionally, ten students have been elected for guideline-based interviews. Central aims of the workshop are the critical discussion of the experiments and activities, the theoretical framework and how theory translates into practise.

Plenary Lecture - 4 by Lucy Avraamidou & Emily McLeod

11:30 - 12:30 Thursday, 31st August, 2023

Chair: William Cobern

1306 Identity-based research in science education: Past, present, and possible futures of the research field and the ESERA community

Lucy Avraamidou[1], Emily MacLeod[2]

[1]University of Groningen, Groningen, Selecteer een gebied, staat of provincie a.u.b., Netherlands. [2]University College London, London, United Kingdom

Abstract

Who we are, how we identify (or not) with science, and how others see us, shape our (dis)engagement with science and science-related subjects in school as well as in out-of-school settings. In this inaugural ESERA Community Plenary, we will map the development of the research area of 'science identities' within science education research over the last two decades. Alongside this, we will detail the role of ESERA and its members in the growth of science identities research. We will begin with a reflection on the emerging discourse on science identities, its promise for science education research as well as its conceptual pitfalls. We will then provide a synthesis of the existing knowledge base on science identities and identify gaps in the literature. We will end with a set of recommendations for future research directions and we will argue about the need for conceptualising science identity as an embodied affair, in which the body is seen as an event instead of an object, and where emotions are central.

Parallel Session - 7.1 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Enas Easa

75 Investigation of the Effects of Gamified STEM Activities in Science Lesson on Student 21st-century Skills Development in Flipped Learning

Hatica Cansu Özpir Mantaş, Mehtap Yıldırım

Marmara University, Istanbul, Turkey

Abstract

The purpose of this research is to examine the effects of teaching practices supported by flipped learning model and gamified STEM activities on the development of 21st century skills in science learning of fifth grade students. Experimental design, one of the quantitative research methods, was used in the research. The study group consists of fifty students studying in the fifth grade of the spring semester in the 2021-2022 academic year. In the study, which was carried out as three experimental groups, gamified STEM activities were applied in the first experimental group, flipped classroom model and STEM in the second experimental group, and gamified STEM activities with the flipped classroom model in the third experimental group. The 21st century skill scale constitutes the quantitative data collection tool of the research. Quantitative data collected after 10 weeks of application were analyzed in the SPSS program. Normally distributed data were analyzed by one-way Anova and paired groups t-test, and data not normally distributed were analyzed by Kruskal Wallis, Wilcoxon Signed Rank test and Mann Whitney –U test. As a result of the analysis, although there was an increase in the post-test mean scores of the groups in the 21st Century skill scale, no significant difference was found.

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126 Inquiry-Based Science Teaching in Primary Schools: Practices and Effects of Various Scientific Activities

Manuel Bächtold, David Cross, Valérie Munier

University of Montpellier, Montpellier, France

Abstract

Data from PISA and TIMSS have recently fuelled the debate on the efficacy of inquiry-based science teaching (IBST). Some analyses of these data show different effects of various scientific activities related to IBST performed with students depending on their frequency of implementation. Extending this research, the present study focuses on several scientific activities (Conception, Problem, Hypothesis, Model, Manipulation, Discussion-IBST, Interaction), some of which have not been considered previously. It investigates the extent to which these activities are implemented in teachers' practices, and their effects on students. The study is based on self-reported practices of primary school teachers in France (N=98) and data on their students (N=2250) collected through a test measuring their scientific knowledge, inquiry skills, views of the nature of science (NOS) and attitudes towards science. Results show that teachers' practices are diverse, with some teachers often implementing scientific activities and others rarely implementing them. Overall, these differences in the practices were not found to imply important differences in students' scientific knowledge, inquiry skills, NOS views or attitudes towards science. The only scientific activity for which several positive relations were found with student measures (i.e., knowledge and NOS view) is modelling. This finding calls for further studies exploring in more detail the different possible practices associated with modelling and their respective effects on students.

136 Design, Development and Evaluation of Experimental Activities on Heat Conduction in Metals at Primary Education

Eleni - Maria Valkanou[1], Ioannis Starakis[2], Anastasios Zoupidis[3]

[1]University of Western Macedonia, Florina, Greece. [2]National and Kapodistrian University of Athens, Athens, Greece. [3]Democritus University of Thrace, Alexandroupolis, Greece

Abstract

From the overview of the international bibliography, it emerges that students of all levels of education tend to consider heat to be a substance with fluid properties. This alternative idea seems to be an obstacle to the conceptual understanding of heat conduction's mechanism because it makes it difficult to understand this phenomenon in terms of energy transfer. The present study is part of a TLS concerning the heat conduction in the 5th grade of Primary School. This paper focuses on the design, development, and evaluation of experimental activities on heat conduction in metals. Ultimate aim was to capture students' learning pathways in this thematic area. Key point for the design of the activities was the confrontation of students' alternative idea that heat is a substance with fluid properties. The study was carried out using the teaching experiment method approach. A 90-minute teaching experiment was designed and applied in 12 5th graders (4 groups of 3 students). Due to the exploratory nature of the research, qualitive content analysis methods were used for the analysis of the data. The results indicate that all the students were able to shift from their alternative idea that heat is a substance towards the scientific view of the concept. The results revealed specific learning pathways, through which students can overcome their conceptual difficulties regarding the concept of heat and be able to construct the scientifically accepted explanation that the heat is conducted with the same rate in all direction in metals.

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111 The Pedagogy of Differentiated Instruction in the Chemistry High Classroom: The Impact of Customized Pedagogical Kits on Self-Efficacy and Attitudes of High School Students and Teachers

Enas Easa[1], Ron Blonder[2]

[1]The Academic College of Law and Science, Hod HaSharon, Israel. [2]Weizmann Instituation Of Science, Rehovot, Israel

Abstract

Chemistry is one of the most difficult scientific disciplines to learn, as the chemical sciences combine abstract theoretical concepts, which require the learner to understand and link the macroscopic level with the microscopic level, using the symbol level. In addition, many studies have shown that quite a few students hold misconceptions about concepts and content learned in chemistry. Which may, according to these studies, block their conceptual and meaningful understanding in the classroom, and affect their performance in chemistry especially when it comes to heterogeneous class. In the present study, we focused on two teaching approaches, RTI- the response to intervention approach, and DI -the differentiated instruction approach.

Using a pedagogical model that combines these two approaches, several customized pedagogical kits(CPKs) were developed as part of the study to detect students' misconceptions about chemistry and overcome them through customized teaching activities. The study examined the effect of these CPKs on teachers and students self-efficacy beliefs and attitudes towards chemistry and differentiated instruction. The study's data was collected by pre-post questionnaires, with a reliability of (α=0.91 of students' self-efficacy, α=0.98 of students' attitudes, α=0.95 of teachers' self-efficacy, α=0.93 of teachers' attitudes) within 96 chemistry high school teachers and 665 chemistry high school students. The findings of the study indicate a significant higher values of self-efficacy belief and attitudes towards differentiated instruction in chemistry among teachers and high school students, in addition to significant higher performance of students in chemistry tasks following the activation of CPKs in the classrooms.

Parallel Session - 7.2 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Gillian Roehrig

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849 Evaluating Genetic Variation as a Disciplinary Core Idea Map Through Different Levels of Schooling – Science Teachers´ Perspective

Helen Semilarski, Helin Semilarski

University of Tartu, Tartu, Estonia

Abstract

Students have difficulties in conceptualizing genetic variation – they have fragmented knowledge of genetic variation and fail to gain a clear picture of how related knowledge is interconnected. This is concerning especially when knowing that genetic variation is a fundamental and disciplinary core idea in biology. Genetic variation is a major origin of phenotypic variation, the engine of evolution, and an important cause of human anatomy. Thus, it is important to teach genetic variation at school in biology lessons, especially when studying human genetics, it has feasible value for human well-being. It is necessary to have an overview of this disciplinary core idea because one perk of studying human genetic variation is the analysis and characterization of the genetic contribution to many human diseases. It is important to show both science teachers and students how the knowledge related to genetic variation is interconnected. This research is identifying the conceptual development of genetic variation through the schooling years (from grade 1 to 12) via created core idea map and research science teachers' feedback on the created map. It is proposed that it is important to integrate developed disciplinary core idea maps into the science lessons to support students' meaningful learning.

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978 The Impact of System Thinking Capability Development on Promoting Students' Thinking Levels According to the STH Model: The Case of Ecosystems and Feeding Relationships

Naji Kortam, Ahmad Basheer, Okla Sbeah

Academic Arab College of Education Haifa, Israel

Abstract

Despite the consensus that system thinking should be nurtured because of its many educational benefits it remains unclear whether teaching methods that develop system thinking increase students' thinking levels as defined in the System Thinking Hierarchical (STH) model. Here 177 8th grade students were assigned to either the experimental group studying "ecosystems and feeding relationships" via traditional teaching incorporating methods that promote system thinking capabilities, such as case studies and constructing concept maps. The control group studied the same unit frontally. The pre-post results showed significant increase in thinking levels in the treatment group vs. the control group, especially in the highest levels. The theoretical and practical implications are discussed.

1198 A Case Study of Undergraduate Biology Students' Engagement in Blended Sensemaking During Mathematical Modeling Tasks

Desi Desi[1,2], Gillian Roehrig[1], Anita Schuchardt[1]

[1]University of Minnesota, Minneapolis, Minnesota, USA. [2]Universitas Sriwijaya, Palembang, South Sumatera, Indonesia

Abstract

Engaging in Blended Sensemaking – using science sensemaking to support mathematics sensemaking or vice versa – has a positive impact on student scientific understanding and problem solving skills. However, prior works have only examined whether blended sensemaking occurs by individual students, not how blended sensemaking occurs when students are working collaboratively in mathematical modeling tasks and the types of sensemaking involved. This case study investigated how blended sensemaking was developed between two individuals working to mathematically model population growth rate. The Sci-Math Sensemaking Framework was used to identify the types of sensemaking. This study found that this pair not only engaged in Individual Blended Sensemaking, they also engaged in Shared Blended Sensemaking. Individual Blended Sensemaking occurred when one of the students were either presenting their ideas or summarizing a discussion. In contrast, Shared Blended Sensemaking could continue over several conversational turns during which students built on one another's sensemaking to generate greater understanding of the phenomenon or the equation. This is the first time Shared Blended Sensemaking has been characterized and the findings suggest that one way to help students integrate mathematics and science sensemaking is to have them engage in pair discussions during a mathematical modeling task. However, these findings may apply more generally to other active learning activities involving

student discussion and may account for why these activities have been shown to improve learning; because they provide opportunities for students to share and build on each other's sensemaking.

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860 An Empirical Study on the Budding of Scientific Inquiry in Early Childhood: Using and Modifying Ycvs for Japanese Context

Kenji Matsubara[1], Kana Suematsu[2], Hideo Kameyama[3], Yuko Kobayashi[4]

[1]National Institute for Educational Policy Research, Tokyo, Japan. [2]Tokyo Kasei Gakuin University, Tokyo, Japan. [3]Nanatsumatsu Youchien, Hyogo, Japan. [4]University of Tsukuba Doctoral Program in School Education, Tsukuba, Japan

Abstract

It is thought that children's various experiences in early childhood create the budding or base for their scientific inquiry (SI). In this study, we applied some components of Young Children's Views about Science (YCVS) (Lederman, J.S. et al, 2014), which try to assess the understanding of SI aspects in young children who have difficulty reading and writing. Then, we tried to modify the survey method to empirically examine the development of scientific inquiry in early childhood in a form suitable for the Japanese childcare content. The preliminary survey was conducted on 22 five-year-old children in 2021 and the main survey on 57 children of the same age group in 2022. The overall results showed that the majority of the targeted children were assessed as naïve in terms of their understanding of SI. The group of children who had direct experience of the phenomena demonstrated a slightly higher understanding of SI. This might suggest that inclusion of direct experience in the interview can help us when assessing the conceptual understanding of SI among children in early childhood.

Parallel Session - 7.3 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Lucas Weinberg

1050 Digital Tools in Preschool Science: To Be or Not to Be

Maria Papantonis Stajcic, Pernilla Nilsson

Halmstad University, Halmstad, Sweden

Abstract

This paper investigates preschool teachers' considerations for including digital tools in their teaching of science to develop children's learning and meaning making of the science content. The ongoing digitalisation in society has affected education, and the use of digital tools has increased significantly. Recent research about digital tools in early childhood teaching focuses

on different aspects of technology implementation. However, there is a gap in the research into what considerations that support preschool teachers' choices of what, why and how they integrate digital tools into their teaching. The reflection tool Content Representations (CoRe) is used to make explicit the teachers' considerations when planning for their teaching. Further video-stimulated recall interviews are used to capture the preschool teachers' reflections on their interactions with children about the specific scientific content. The Refined Consensus Model (RCM) was used as a theoretical framework for analysing the data. The results show that the considerations involved links to the scientific content and other modes, to make the abstract concrete and stimulate engagement and creativity. Consequently, digital tools act as a mediating resource in the learning and meaning making of science content.

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985 Visualization of Translations of Frame of Reference with the Help of 360-Degree-Videos

Eliane Merki[1], Sarah Hofer[2], Volker Eisenlauer[3], Andreas Lichtenberger[1]

[1]ETH Zürich, Zürich, Switzerland. [2]LMU München, München, Germany. [3]UniBw München, München, Germany

Abstract

The aim of this study is to evaluate the use of 360°-videos in high school physics classes. For this purpose, we created an immersive and interactive learning environment for teaching and learning about frames of reference. Students were given the option of choosing a certain setting before exploring a filmed uniform motion and watching the formation of a corresponding position-time-diagram in real-time. In a randomized controlled intervention study with a pre-/post-test design, we examined whether the 360°-video-environment enhances students' learning and engagement. We developed and validated a new reference frame concept test (RFCT) to investigate the learning progress, which exhibited satisfactory psychometric properties. In total 270 high school students (141 intervention group, 120 control group) participated in our study. After performing a Shapiro-Wilk-Test and a Levene-test for the common items of the pre- and posttest, a t-test for the normalized gain $t(270) = -1.5$, $p = 0.1$, $d = 0.2$) showed no significant effect between the groups. The pre-and posttest scores also show no significant difference between male and female participants (f 5.6, STD 1.7, m 5.9 STD 1.7). The engagement items showed a small tendency in favour of the intervention group.

1091 The Effect of the Instructional Technologies Course Taught With the Blended Learning Model on the Pre-Service Teachers' Self-Efficacy Beliefs in Quick Web 2.0 Content Development

Betül Karaduman, Pınar Fettahlıoğlu

Çukurova University, Adana, Turkey

Abstract

The aim of this study is to determine the effect of the instructional technologies course taught with the blended learning model on the pre-service teachers' self-efficacy beliefs in developing content quickly. The study group consists of 50 science teacher candidates (25-experimental group, 25-control group) who attend the science teaching program and take the instructional technologies course. A mixed method was used as a research design; particularly, a special type of Concurrent Nested Strategy was applied. The quantitative portion was based on the a quasi-experimental design with unequal pretest-posttest control group from the quantitative research, and the qualitative portion was based on the holistic multiplecase study method. The quantitative portion of the research was conducted with 25 (experimental group), 25 (control group) second-year pre-service science teachers studying at a state university. The qualitative portion of the study was conducted with six pre-service science teachers selected among the 25 (experimental group) pre-service science teachers based on the pre-test results obtained from quick content development self-efficacy belief scale. As quantitative data collection tools, the web 2.0 quick content development self-efficiency scale developed by Birişçi et al. (2018) were used. As a qualitative data collection tool, a semi-structured opinion form developed by the researchers was used. t tests for dependent groups and independent sample t-test were used to analyse quantitative data. Both descriptive and content analyses of the qualitative data were performed. In the analysis of the data, it was determined that only the students in the experimental group developed web 2.0 quick content development self-efficiency belief.

1092 Freeze for Future - Young People Create Virtual Glacier Worlds for Future Climate Change Education

Lucas Weinberg, Johanna Trummer, Lars Keller, Suzanne Kapelari

Universität Innsbruck, Innsbruck, Austria

Abstract

Climate change and glacier retreat are no longer a far-away future's forecast, rather they are the present. Due to Austria's geographic location in the Alps, glaciers represent an important climate change indicator and are therefore an indispensable part of climate change education. Only in a few years, several glaciers in Austria will not be accessible any longer for the purpose of education due to the consequences of climate change. Therefore, this study based on the project "Freeze For Future" wants to use today's window of opportunity to conserve the glacier's current state for future climate change education settings by creating a virtual environment. The field of virtual reality in combination with classroom education is increasing steadily, because of the additional possibilities that arise through the phenomenon of immersion. Immersion triggers motivation and engagement comparable to experiences in real world settings. However, as little scientific studies have been conducted in this field so far, this research gap will be addressed by accompanying didactic research that focuses on the study's evaluation as well as the underlying educational theories in the context of virtual reality. Following a citizen science approach, approximately 870 students will cooperate and research together with

climate change experts as well as from the field of data technology to create a virtual reality environment. The project is structured as an iterative three-year cycle which consists of a pre-post design, the collection of pre-conceptions and the execution of semi-structured interviews.

Parallel Session - 7.4 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Ebru Kaya

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8 How Students View Social-Institutional Systems of Nature of Science?

Dilara Gören, Ebru Kaya

Boğaziçi University, Istanbul, Turkey

Abstract

This study as a part of a broader project examines the students' views about social aspects of nature of science (NOS) within theoretical lens of Erduran and Dagher's (2014) reconceptualization of Family Resemblance Approach (FRA). This approach characterizes science as epistemic-cognitive and social-institutional systems. The social-institutional systems as being at the focus of the study includes 7 sub categories; scientific ethos, social certification and dissemination, social values, professional activities, political power structures, social organization and interactions and financial systems. The quantitative data was gathered to portray general trend through a questionnaire while interviews as qualitative data allowed to examine students' views of social-institutional systems (SI) of science. A total of 701 middle school students from 5th to 8th grade answered the questionnaire and 12 students among them were selected for the interview. The results showed that students have slightly higher understanding of SI. Most (81%) agreed item was related with protection and respect for environment as social values category. Most students (55%) were unsure on the effect political decisions on science. In the interviews, the students were able to explain and give examples for professional activities of scientists, the importance of dissemination of knowledge, scientific ethos, and social values. However, the students couldn't elaborate how political power structures, financial issues are connected to science and social organizations that scientists collaboratively work within socially organized system. They viewed government as a control mechanism for scientific studies and the financial need for only science equipment. The results suggest that classroom implementation may target those categories for broadening students' views around these social-institutional aspects of NOS.

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13 Science Teachers' Views on Nature of Science and its Inclusion in the Science Curriculum

Gözde Kurt, Ebru Kaya

Bogazici University, İstanbul, Turkey

Abstract

Reconceptualized Family Resemblance Approach to Nature of Science (RFN) which is one of the Nature of Science (NOS) approaches constitutes the theoretical framework of the study. The RFN includes the cognitive-epistemic system consisting of aims and values of science, methods and methodological rules, scientific practices, and scientific knowledge categories and the social-institutional system. Moreover, the RFN is a pedagogically applicable approach that sees the cognitive-epistemic and social-institutional systems holistically. The study aims to explore science teachers' views on NOS and the inclusion of NOS in Turkish science curriculum. 10 science teachers from different school types, teaching experiences, educational background, and gender were selected by purposeful sampling technique. As instruments, the semi-structured interview protocol and the RFN Questionnaire were used. While the thematic analysis was applied for qualitative data gathered through the interviews, the descriptive statistics were applied for quantitative data from the questionnaire. The results of the analysis of RFN Questionnaire data show that the science teachers have high or moderate level of RFN understandings. However, according to the findings of the interviews, it was found that the science teachers have some limited or naïve views about the RFN categories even if they expressed some sound explanations. Furthermore, some science teachers stated that NOS inclusion in the Turkish science curriculum is limited especially for the social-institutional system. There is a consistency between the science teachers' views on NOS and the inclusion of NOS in the science curriculum. The science teachers also gave some suggestions to integrate NOS into the science curriculum such as the inclusion of NOS as a topic, example, and objective. The study suggests that the number of in-service teacher trainings about NOS should be increased and NOS should be integrated into the science curriculum explicitly by using the RFN viewpoint.

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901 A Qualitative Study about Socially Shared Regulation during Experimentation in Physics

Sarah Hohrath[1], Heiko Krabbe[1], Sandra Aßmann[1], Maria Opfermann[2]

[1]Ruhr University Bochum, Bochum, Germany. [2]University of Wuppertal, Wuppertal, Germany

Abstract

When experimenting in a physics out-of-school lab, students get the possibility of working hands-on minds-on, conducting experiments collaboratively and regulating their own learning process. This can be challenging due to missing prior knowledge or different levels of metacognitive conditions. Since the students work in groups, different types of regulation can occur: self-regulation, co-regulation and socially shared regulation. Further, materials influence

the learning and group working process as they can be used to demonstrate abstract or non-visible concepts. In our qualitative study, we investigated how do students jointly regulate their cognitive and metacognitive processes (RQ1) and what is the role of materials in experimentation in terms of cognitive and metacognitive processes (RQ2). Our research is exploratory in nature. Our total sample consists of N = 142 seventh and eighth grade students, who participated in our out-of-school project day about geometrical optics. Randomly chosen, 12 groups of 3 students were recorded on video. We selected two groups for a detailed analysis which represented contrasting cases in terms of displayed behavior with respect to their shared regulation of cognitive and metacognitive processes. At the moment we only have preliminary results of the analysis indicating that group roles can shift from more co-regulated to more socially shared regulated and vice versa. Further, we found that materials are mostly used for supporting own explanation attempts, but not for understanding other group members' ideas. Our preliminary findings seem important because they can explain students collaborative learning within different group constellations during experimenting in physics and the role materials play during a collaborative learning process.

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496 Understanding Social Justice in Secondary Science: The Views of Students in Initial Teacher Education

Wilton Lodge, Michael Reiss, Marian Mulcahy

University College London, London, United Kingdom

Abstract

Structural inequalities exist in the education systems of many western democracies, to the disadvantage of large numbers of students. What remains under-researched is whether these disadvantages are either reinforced or tackled by new entrants to the teaching profession. Accordingly, in this study we pose the research question 'How do secondary science initial teacher education (ITE) students understand social justice, and what do they believe should be role of secondary science ITE in contributing to it?'. Thirty secondary science ITE students at a university in England participated in interviews that were audio-taped and professionally transcribed. Transcripts were analysed using deductive qualitative content analysis. Findings revealed that while school science was seen as having a role in challenging issues of under-representation, only a minority of students manifested a more critical engagement with issues of how science is portrayed. There were few examples of antiracist science pedagogy being advocated or of feminist critiques of how science is presented and communicated.

Parallel Session - 7.5 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Clément Maisch

153 Science Teachers' Technological Pedagogical Content Knowledge: A Mixed-Method Study

Mine Tanrisevdi[1], Jale Cakiroglu[1], Sedef Canbazoglu Bilici[2]

[1]Middle East Technical University, Ankara, Turkey. [2]Gazi University, Ankara, Turkey

Abstract

The aim of the current study is to investigate science teachers' technological pedagogical content knowledge (TPACK) competencies, and determine their indicators based on the TPACK-Deep framework. The study was followed by an explanatory sequential mixed-method design. Participants were 136 science teachers and three of them having different TPACK competency was selected for the multiple case study. Data sources were the TPACK-Deep scale, classroom observations, video recordings of the instruction, and semi-structured interviews. The findings showed that science teachers' TPACK competency was high. In this regard, teachers' scores were the lowest on the proficiency factor and highest in the ethics factor. For the qualitative part, although the teacher with a high TPACK competency showed more TPACK indicators than the teachers having medium and low competency, the overall TPACK indicators were low in number considering the overall indicators. The current study showed that science teachers' self-assessment scores and their self-reporting do not fit with their TPACK-in-action behavior and indicators.

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469 Video as a Didactic Resource to Teach About the Cerrado (Brazilian Savannah) in the Classroom: The Perception of Science Teachers

Samuel Schnorr, Ana Julia Pedreira

University of Brasilia, Brasilia, Brazil

Abstract

This research was developed in two stages: in the first, we investigated whether and how science teachers of Brazilian schools address the Cerrado Biome, the Brazilian savannah, in their classes. In the second, we analysed i) if and how science teachers use videos as a didactic resource in their pedagogical practices and ii) their perception on the usefulness for teaching of a scientific dissemination video about ecological interactions of Cerrado lagoons. For this, we conducted exploratory and descriptive research from two questionnaires. The answers were evaluated with the help of content analysis. Our results show that the Cerrado is still superficially addressed in the schools researched, and the teaching of the biome is out of the context of the student's experience. The answers obtained show that the teachers have a tendency to use

videos in the classrooms, however they face difficulties in doing so, mainly due to limitations of technological resources. Finally, the teachers evaluated that the video about the Cerrado is related to the student's reality and that it would be essential for a contextualized and critical education, especially regarding Cerrado preservation and its defence against harmful anthropic actions.

734 (Not) Learning Alone With Augmented Reality: Continuing Results From a Comparative Study in an Undergraduate Physics Laboratory Course

Thomas Sean Weatherby[1], Sebastian Kapp[2], Michael Thees[2], Fabian Beil[2], Jan-Philipp Burde[3], Thomas Wilhelm[1], Jochen Kuhn[4]

[1]Department for Physics Education Research, Goethe University, Frankfurt am Main, Germany. [2]Physics Education Research Group, TU Kaiserslautern, Kaiserslautern, Germany. [3]Physics Education Research Group, Eberhard Karls University, Tübingen, Germany. [4]Chair of Physics Education, Faculty of Physics, Ludwig Maximilian University, Munich, Germany

Abstract

The pandemic meant we spent a lot of time in video calls and remote teaching and learning. Other methods of teaching and learning, such as laboratory practical work, were not so easy to digitise from their in-person forms, due their reliance on work in small groups. As part of an ongoing investigation into differing types of media and representational forms, this juncture necessitated taking social forms into account. Carried out in summer semester 2020, this investigation looks to compare the cognitive load, learning gains and system usability of two different apparatus for the display of measurement information for a set of eight small inquiry practicals on simple DC-Circuits in an undergraduate practical course for learners with physics as a minor. In the first condition ($N_{\text{Tablet 2D}} = 28$) voltage and current information is displayed on a spatially separated dashboard style array of analogue dials for each circuit component (Tablet 2D condition). This same visualisation is used in the second condition ($N_{\text{Tablet AR}} = 23$), however, these same virtual dials are shown in Augmented Reality (AR), floating above each real component when viewed through the tablet camera (Tablet AR condition). We report no significant differences in cognitive load perceived under either condition and no learning gains under either condition. This is the case despite "excellent" system usabilities of $M_{\text{Tablet 2D}} = 82.0$ (SD = 17.7) and $M_{\text{Tablet AR}} = 84.6$ (SD = 13.3) respectively. These findings are discussed with reference to prior work.

534 How Metrological Concepts Are Introduced in Biology Courses in Higher Education?

Clément Maisch[1], Myriam REGENT-KLOECKNER[1], Christophe DAUSSY[2]

[1]CY Cergy Paris Université, Cergy, France. [2]Univeristé Sorbonne Paris Nord, Villetanneuse, France

Abstract

Natural sciences are built on qualitative and quantitative observations of the world in various experimental situations. Measurements obtained make it possible to objectify these observations but require a definition of the quantities studied. However, the observable characteristics depend on the objects themselves and on the theoretical questioning underlying the observations. The definitions, the activities and the interpretations of measurements are a priori dependent on the disciplinary specificities. Measurements are central in scientific research. They should have a similar role for scientific teaching from kindergarten to higher education. In this exploratory study, we investigate the metrological concepts and methods involved in the first year of a bachelor's degree of biology courses. This study explores course materials provided to students for exercise and practical sessions and the associated teaching goals through interviews of teachers. Our analysis method allows us to characterise the concepts and methods of metrology existing in course materials. These preliminary results show us that metrology is a poor subject of interest in first year biology courses.

Parallel Session - 7.6 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Mustafa Alyar

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215 Analysing Digital Stories about the Climate Crisis

Güliz Karaarslan Semiz[1], Kathrin Otrel Cass[2], Birgül Çakır Yıldırım[1]

[1]Ağrı İbrahim Çeçen University, Ağrı, Turkey. [2]University of Graz, Graz, Austria

Abstract

Storytelling has been described as a promising format to give people a voice to share their thoughts with others, in particular in the context of environmental education. Storytelling in modern times means that stories are also taking on digital formats, allowing the storyteller to use various media to emphasize through more than written words intentionalities for instance through the use of videos, images or sound and/or share stories through digitized channels. Due to the subjective nature of the narratives that are being shared the analysis of such stories is challenging. While there are a number of studies reporting on the pedagogical benefit of using digital storytelling, there is a lack of research detailing the analysis of digital stories produced by students. Given the popularity of digital storytelling in education and the possibility storytelling offers to strengthen environmental education were looking for a suitable framework for the analysis of such stories. We present a framework for analysis that was developed from a framework for transformative global citizenship education (TGCE) and a framework to analyze multi model stories. We expanded the TGCE framework of four dimensions, namely politics (ideology), social (collective), self (subjective) and praxis (engagement) with an emotional (care) dimension. We present the application of this

framework in the analysis of digital stories that were prepared by secondary school students as part of the "Change the Story" project. We conclude by detailing the affordances of this framework and share how the students' stories showed 'environment as a process' (not as an object) where they expressed their preparedness to care for the environment, through explicit references of taking responsibility, being motivated and willing to protect the environment.

1147 Visualtech: Augmented Reality for Art to Meet Science

María Napal[1], Javier Osés[2], Isabel Zudaire[1], Irantzu Uriz[1], Lander Calvelhe[1]

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Abstract

Emerging technologies such as Augmented Reality (AR) and 3D animation enable the creation of surprising images and effects that capture the attention of the spectator, and foster comprehension of certain phenomena; for example, overcoming the limits imposed by scale to show complex and abstract concepts. This contribution describes a project (Visualtech 4.0) that links science and technology with a didactic perspective on science and arts. High-impact, artistic pieces of work are integrated into science teaching activities to be used in formal and informal teaching. To this end, optic microscopy images of materials subjected to various treatments will be merged into AR and 3D animations; this will allow the unfolding of the complex physical concepts involved, and adapting the didactic content to different user profiles. The project includes 4 activities, which involve a university, a research centre and various firms. It is expected to generate knowledge on STEM areas (Science, Technology, Engineering, Arts & Maths) and to foster scientific vocations, independent of the gender of the learner.

1167 CHATGPT for Next Generation Science Learning

Xiaoming Zhai

University of Georgia, Athens, Georgia, USA

Abstract

The K-12 Framework for Science Education set forth a vision for Next Generation Science Learning, which is to engage students in scientific practices to learn and use disciplinary core ideas and crosscutting concepts. This vision posits significant challenges in terms of how to track students' learning, provide feedback and learning guidance, recommend learning materials, and meet the special needs of students with diverse backgrounds. This study pilots ChatGPT in meeting these challenges. I used one performance expectation of the Next Generation Science Standards to develop a prompt, using which ChatGPT automatically generates a performance-based assessment task. I supplied a response and asked ChatGPT to grade and provide feedback. I then asked ChatGPT to provide learning guidance and learning materials based on the response. At last, I told ChatGPT that the learner was with dyslexia, and

eventually ChatGPT recommended specific learning materials for the learner. Results suggest that ChatGPT has the potential to tackle the most challenging problems of science learning through automatic assessment development, automatic grading, automatic learning guidance, and automatic recommendation of learning materials. Even with exciting findings, this study suggests that ChatGPT cannot substitute teachers. Teachers need professional knowledge to use ChatGPT for instructional purposes. Further, the BlackBox of ChatGPT, in terms of how it generates automatic results, needs to be explainable so that users can fully appreciate it.

1240 The Redundancy Principle in Action: How Effective Are the Instructional Videos?

Mustafa Alyar, Faik Özgür Karataş

Trabzon University, Trabzon, Turkey

Abstract

The development of information technologies and the need for distance education, which has become more evident with COVID-19, have made the use of videos as a teaching tool quite common. However, instructional design principles should be taken into account in the creation of videos for effective teaching. In this respect, it is important to examine both newly created videos and previously prepared videos in terms of instructional design. Cognitive Theory of Multimedia Learning (CTML) is one of the widely used theories about instructional video design. In line with this theory and within the framework of Cognitive Load Theory, the redundancy principle, which is one of the multimedia design principles, comes to the fore in the transmission of instructional content. In this principle, it is claimed that presenting the content to learners with images and narration is more effective than presenting it with images, narration, and on-screen text. Determining to what extent they comply with this principle in educational videos published by public or private institutions will support the creation of new content. For this reason, this study is aimed to examine the videos prepared on mixtures, one of the basic subjects of chemistry at the high school level in Turkey, and made available to teachers and students in terms of the redundancy principle. The study was carried out according to the document analysis method. The videos included in the study were analyzed by descriptive content analysis method. As a result of the examination, it was found that, contrary to the redundancy principle, in most of the videos, on-screen text accompanies the narration, out-of-topic images are included, and on-screen text is used intensively without using images. In this respect, it was concluded that the redundancy principle is largely ignored in the videos.

Parallel Session - 7.7 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Hagen Schwanke

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96 Development and Implementation of Digital Game-Supported Argumentation Activities: A Design-Based Research

Seda Okumuş[1], Suat Ünal[2], Zehra Özdilek[3], Yasemin Koç Gözübenli[4]

[1]Ataturk University, Erzurum, Turkey. [2]Trabzon University, Trabzon, Turkey. [3]Bursa Uludağ University, Bursa, Turkey. [4]Hatay Mustafa Kemal University, Hatay, Turkey

Abstract

In the 21st century, changing student characteristics have brought digitalization to the forefront of the teaching process and technological applications have begun to be used more in lessons. Accordingly, the use of digital games, which enable students to have fun while learning science, has started to gain importance. This study falls under the category of design-based research and covers the development and implementation of digital game-supported argumentation activities. In total, 16 argumentation activities on four sub-topics such as the "Matter and Heat" unit and a digital game for the unit were designed and developed. The application was performed for eight weeks with 36 6th-grade students in Trabzon, Turkey. During the instruction of the unit, argumentation activities were observed by an argumentation observation form. Students' views about the argumentation practices and the digital game used in the teaching process were determined through interviews. According to the findings, the argumentation process with the digital game was effective in teaching the "Matter and Heat" unit. Surprisingly, the results from both data collection methods revealed that because there were so many argumentative tasks and they took so long, students became disinterested in the applications. The activities that the students struggled with or had trouble understanding were identified as a result of the study, and argumentation activities that were more ineffective at grabbing the students' attention were eliminated in order to help the students complete the argumentation process more successfully and the teacher finishes the unit within the time allotted by the curriculum. The study's findings on students' opinions of digital games revealed that they preferred them and offered some improvements.

1261 A Case Study on the Evaluation of Language-Based Science Activities

Banu Kara[1], Elif Benzer[1], Aysel Gökçe[2]

[1]Marmara University, Istanbul, Turkey. [2]Şişli Bilim ve Sanat Merkezi, Istanbul, Turkey

Abstract

The purpose of this research is to implement language-based science activities and to evaluate these activities in line with teacher observations and student opinions. In the study, case design,

one of the qualitative research methods, was used in order to examine language-based science activities in depth. The research was carried out with the participation of 12 volunteer students attending the 7th grade in different educational institutions in Istanbul. Within the scope of the study, 6 lesson-hour training on the subject of "Particulate Structure of Matter" was held online with the students. Language-based science activities in education; vocabulary worksheet, what I know-what I want to know-what I learned (KWL) charts, semantic map, think-pair-share, V-diagram, persuasive writing, jigsaw, talk cards and science diary activities were applied. Student opinion forms and teacher observation notes were used as data collection tools in the research. Descriptive data analysis method, which is one of the qualitative data analysis methods, was used in the analysis of the data, since the data were obtained through opinion form and observation. As a result of the research, it was determined that the activities were strong in terms of being fun, remarkable and understandable, but weak in terms of short implementation time, technical problems, limited student interaction and insufficient prior knowledge of the students. More time, more social interaction and face-to-face training are recommended for improvements in the implementation of the activities.

1209 Characterizing Whole-Class Dialogues and Different Purposes in an Inquiry Based Teaching Unit

Idar Mestad[1], Jørgen Stange Larsen[1], Stein Dankert Kolstø[2]

[1]Western Norway University of Applied Sciences, Bergen, Norway. [2]University of Bergen, Bergen, Norway

Abstract

This case study aims to characterize different types of dialogues in science related whole-class discussions as part of teaching units aimed to make students to use authentic data and measurements to inquire into controversial issues. The teacher moves and the students' responses in four lower secondary classes are analysed. Most of the whole class discussions took place after the students had discussed a teacher question in groups. The dialogue types are divided into three main types based on the categories from Walton's framework the new dialectics: Information-seeking, persuasion, and inquiry. Further the study present sub-categories which aim to identify the teachers' and the students' goal of the different dialogues. The study discusses whether the different dialogue types contribute to a common understanding between the teacher and students about purposes of the dialogues. Further this can be used to get insight into how different purposes and considerations contribute or hamper the student ability share, justify or test own ideas in whole class discussions.

1030 Augmented Reality Used in Physical Student Experiments – A New Way to Cognitive Destress Students and Enhance Their Interest?

Hagen Schwanke, Thomas Trefzger

University of Würzburg, Würzburg, Bayern, Germany

Abstract

We present a novel approach to visualize scientific concepts in an accessible way to enhance teaching experience in physics education. Dealing with scientific models involve a high degree of complexity for the learners. Both cognitive stress due to complexity as well as external stress based on the presentation of the content negatively impact learning efficiency. Our objective is to study if the use of augmented reality in physics education can reduce extrinsic stress associated with physics lab experiments and to study the impact on their situational interest in connection with learning environments which are provided with simulations on a tablet or classical reply cards. In order to do that, we overlap digital content to real-life lab experiments and improve spatial and temporal contiguity of scientific theory and experiment in the augmented reality learning environment. Otherwise, we use simulations on a tablet which are separated from the real-life lab experiment and classic reply cards which are two dimensional printings. The applications for the simulation and the AR application "PUMA : Magnetlabor" were specially designed and have already been evaluated in qualitative usability study. A comparative study was planned and carried out to evaluate which of the presentation forms have an impact on the extrinsic load and situational interest. In this study, the focus is on the individual perspective of the students, so that all participants experience all three forms of performance. Data collection is currently taking place and will be completed in February 2023. First results will be presented on the ESERA 2023. This lecture gives an exemplary insight into a learning station. In addition, the study design and the research questions are presented. The concluding discussion deals with the evaluated data and refers to the research questions.

Parallel Session - 7.8 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Francesca Monti

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142 The Effect of Interdisciplinary Science Teaching Course on Pre-Service Science Teachers' Integrative STEM Teaching Intentions

Asli Koculu, Mustafa Sami Topcu, Mustafa Arslan

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Abstract

The aim of this study was to examine the effect of interdisciplinary science teaching course on pre-service science teachers' integrative STEM teaching intentions. A single group pre- and post-test model was conducted in current research. The sample of the study consists of 40 pre-service science teachers (PSTs) enrolled in 'Interdisciplinary Science Teaching' course. The data were collected with 'Integrative STEM Teaching Intention Questionnaire'. In the data analysis, the paired sample t test was used. Results revealed that there was a statistically significant difference among pre- and post-test total and sub-dimension scores of PSTs' integrative STEM

teaching intentions in favour of the post-test scores. In other words, Interdisciplinary Science Teaching course is effective for developing PSTs' integrative STEM teaching intentions.

605 Science and Mathematics Identities, and Connection to Nature Impact Students' STEAM Career Interests

Michelle Parslow[1], Katherine Vela[1], Rita Hagevik[2], Kathy Trundle[1], Laura Wheeler[1]

[1]Utah State University, Logan, Utah, USA. [2]University of North Carolina, Pembroke, North Carolina, USA

Abstract

There are more STEM careers globally than students, especially females, who pursue STEM careers. Females have similar abilities as males to do so, but less of them select this career track. Science (SI) and mathematics identities (MI), along with students' connection to nature (CN) are related to students' career choices. Gardens have the potential to strengthen students' STEM identities and their connection to nature. To increase motivation for learning STEM, improve students' mathematics and science identities, and encourage interest in STEM careers, STEAM education might provide an answer. We investigated potential differences between male and female students in their MI, SI, and CN. We then looked at the relationship between these variables and students' interest in pursuing a STEAM career. We used Cohen's d effect sizes, t-tests, and correlation matrices to analyze the data. No statistically significant differences were found between male students and female students for MI. However, we found a significant difference between male and female students for SI and CN. Male students expressed higher levels of SI while female students expressed higher CN. We found statistically significant positive correlations between (a) MI and SI, and interest in science, mathematics, technology, and engineering careers; (b) SI and CN, and interest in science, mathematics, technology, and engineering careers; and (c) CN and interest in science, mathematics, and art careers. There were several significant positive correlations between interest in individual STEAM careers and interest in other STEAM careers. These results support the integration of arts into STEM as well as the inclusion of a garden-based learning curriculum to encourage, nurture, and prepare students (especially females) for STEM careers.

607 An Interdisciplinary, Guided Inquiry Approach to Teaching Science and Mathematics in the Early Years

Russell Tytler, Peta White, Melinda Kirk

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Abstract

A significant issue for the teaching and learning of integrated STEM curricula is the maintenance of disciplinary integrity while drawing on the strengths offered by interdisciplinary settings (English & King, 2015; Honey, Pearson & Schweingruber, 2014; Authors, 2019). In this paper we describe an interdisciplinary approach to teaching and learning mathematics and science

in the primary school that draws on two significant innovations: 1) a pedagogy based on students constructing, evaluating and refining multimodal representations in each subject (Authors, 2013, 2020) the design of learning sequences where the epistemic practices of each subject are temporally intertwined (Authors, 2020) such that new learning occurs in each subject in a mutually supportive manner. The model of interdisciplinarity is explored through a case study of a Grade 2 learning sequence on plant growth using Lehrer and Schauble's (2004) approach to Fast Plants. We describe the design principles through which the sequence was structured to open up new learning in each subject, the pedagogy used by teachers to support interdisciplinary learning, and present evidence of significant learning gains in knowledge of plant growth and reproduction, and measurement and data representation, through examination of student representational artefacts, interviews with students, and pre- and post-test results of student mathematical representational work. We interpret student gains in conceptual understandings through a Peircean semiotic lens related to multimodal transduction processes. Through these analyses we argue for an approach to interdisciplinarity that operates through explicit design principles that open up mutually reinforcing epistemic practices particular to each of the STEM disciplines.

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531 Connecting Physics Education and Cultural Heritage: An Nterdisciplinary Didactic Proposal About Near Infrared Vision of Artworks

Francesca Monti, Claudia Daffara, Nicole De Manincor

University of Verona, Verona, Italy, Italy

Abstract

We present an innovative, interdisciplinary didactic module about Infrared Reflectography (IRR) and Infrared False Colour (IRFC) imaging of artworks that allows introducing the properties of the Near Infrared (NIR) range of the electromagnetic spectrum and improving students' understanding of the colour image formation process. Our proposal is centred on the direct application of optical techniques in the NIR to non-invasive diagnostics of paintings and is jointly conducted by physicists together with an art historian expert in heritage science. The teaching sequence is based on laboratorial activities including the use of do-it-yourself materials as well as professional instrumentation and ideally extends a former didactic module focused on the visible range and on colour vision of artwork. It was proposed to various groups of students from different high schools and increasingly refined over time. Our investigation of the learning outcomes shows that this interdisciplinary and practical didactic path succeeds in fostering students' (particularly female students') attitude towards learning physics and represents an effective way for introducing advanced topics in the field of optics and modern physics already at the high school level. We found that IRR allowed students to well understand the properties of electromagnetic radiation in the NIR range as related to radiation-matter interaction while IRFC represents a more challenging subject that opens the way to untying some important conceptual knots related to colour image formation.

Parallel Session - 7.9 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Mukadder Baran

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221 Analysis of Postgraduate Students` (Teachers`) Views on STEAM Education

Medine Baran[1], Mukadder Baran[2], Abdulkadir Maskan[1]

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Abstract

The aim of this research is to examine teachers` views on STEAM education. Sixteen teachers, who were studying master degree at a state university in department of the mathematics and science education participated. Participants were selected based on purposive sampling, and data were collected through eight open-ended structured interview forms. The obtained data were analyzed with qualitative content and descriptive techniques. Two researchers analyzed the data, and necessary calculations were made for reliability. In light of analysis, the teachers indicated that STEAM education is product-oriented, provides permanent learning, and they made definitions in terms of its structure, activities, and effect on learning. Furthermore, the teachers emphasized that STEAM education is essential, in terms of its impact on developing science education, and its necessity for students to establish real-life connections. They also indicated that there were various problems in STEAM education applications, such as problems arising from the education system, lack of materials in learning environments, classroom sizes, lack of physical conditions such as budgetary problems, curriculum, lack of adequate STEAM training, and individual problems arising from teachers and students. Based on the findings it is important to solve the problems especially in implementing STEAM education activities. It is considered necessary for the quality of STEAM education to provide adequate in-service training to teachers to create sufficient physical conditions for STEAM education. The Ministry of National Education can also carry out informative activities to eliminate the negativities existing in STEAM education for students and teachers.

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508 Pre-Service Science Teachers' Risk Perception and Attitudes Towards the COVID-19 Pandemic

Leandro Silva, Maurício Pietrocola

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Abstract

Making decisions about everyday situations in the contemporary world is a complex task. From buying food at the supermarket, to knowing how to protect yourself during an infectious

outbreak requires establishing priority scales based on judgments that involve rational thinking in knowledge of various types, reliable information and values. Despite the fact that COVID-19 pandemic is not the first epidemic of the 21st century, its scope and consequences reflect the pace of international movement of people, goods, services and risks. Understanding these relationships requires a reformulation of thought, both due to their complexity, whose knowledge of which is little or poorly related to the disciplinary subjects. Therefore, it is necessary to privilege knowledge that helps students to discuss on dilemmas, such as the case of the COVID-19 pandemic. To understand the relationship between risk perception and attitudes towards the COVID-19 pandemic we asked undergraduate students to answer a questionnaire after a 16-weeks course structured to contemplate risk situations. Results shows that students' attitudes are grounded in their personal opinions, although these students already have a good relationship with science knowledge and science in general due to the their academic background, which led us to believe that the course improved their original opinions by showing them new perspectives about science knowledge. Results also shows that they developed competences related to rational thinking of possible scenarios.

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705 Investigation of Science Teachers' Nature of Engineering Views

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Abstract

The purpose of the study is to examine science teacher's views about the nature of engineering in central Anatolia in Turkey. The qualitative research method is utilized. Nine science teachers participated in this single holistic case study. The qualitative research method utilized in this study. Data were analyzed by using a coding method. At the end of the study, teachers' views on the nature of engineering differ in some ways. In particular, the answers to the questions related to demarcation, and engineering design process aspects vary. The teachers provided approximately the same answers to the questions asked for the tentativeness and creativity aspects. They thought that engineering design can change and engineering uses creativity and imagination. However, their reasons were also different. Regarding the social and cultural embeddedness aspect, few participants thought that engineering is affected by society. Regarding the subjectivity aspect, the majority thought that engineering does not have a unique solution. Lastly, under the social aspect of engineering, most teachers talk about engineers working as a group, but the answers to advantages and disadvantages differ.

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894 The Place of Paloecology in Biology Teaching

Selin Şahin[1], Serap Öz Aydın[2], Ali Murat Kılıç[2]

[1]Ministry of Education, Balıkesir, Turkey. [2]Balıkesir University, Balıkesir, Turkey

Abstract

While biology teaching mainly deals with topics related to living life, the components of the discipline of paleontology, which has a much wider field of study, are often ignored. To look at the whole picture from a broader perspective, a teaching approach based on understanding both the emergence and development of living life and the evolution of the world that hosts these living things will make biology teaching more effective. Palaeoecology, a branch of science that examines the relationships of living things that lived in the past with each other and their environment, has an essential place in this sense. This study discusses the relationship between Biology and Palaeoecology and the location of Palaeoecology in Biology teaching.

Parallel Session - 7.10 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Hendra Agustian

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37 Teaching About Disease: Lessons From the Pandemic

Martin Braund

Nelson Mandela University, Port Elizabeth, Eastern Cape, South Africa

Abstract

The educational world has often been negatively impacted by the COVID-19 pandemic. This positional paper deals with one positive outcome: how experience of the pandemic might shape, for the better, future teaching about disease and, in a wider context, teaching in 'Life Sciences' and STEM more generally. Four overlapping spheres of learning are proposed that emerge from experience of COVID-19 and are ripe for change: core knowledge about disease, epidemiology, the environmental origins of zoonotic disease and critical thinking and literacy required to engage with the social practices of life sciences within the social-political milieu. The epistemological and pedagogical stance called for is one that challenges neo-conservative traditionalism and technical-instrumentalism, to propose instead, a re-evaluation and re-visioning of teaching and learning, based on social justice and informed critical literacy that ultimately provides emancipatory knowledge.

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41 Investigating Informal Reasoning in Proximal and Distal Contexts of Socio-Scientific Issues

Özlem Özdemir, Devrim Güven

Boğaziçi University, İstanbul, Turkey

Abstract

This study aims to investigate informal reasoning patterns of pre-service science teachers (PSTs) in resolving two socio-scientific issues: proximal (Use of Processed Foods in Turkey) and distal (Production and Use of GMO called Golden Rice in Vietnam). Nineteen pre-service science teachers who were selected purposefully participated in this instrumental multi-case qualitative study. Participants, individually, were asked to respond to the same interview questions about two SSI scenarios prepared by the researchers to be paralleled to each other in terms of general theme, balanced evidence, and structure. Final versions of the scenarios were created by considering the feedback from the experts. Data was analyzed deductively by using the categories established by the (Sadler & Zeidler, 2015) to identify informal reasoning patterns of the participants. Findings indicated that participants displayed more rationalistic thinking (evidence and logic-based) in the context of distal SSI - Golden Rice while displaying more emotive (care-based) informal reasoning in the context of proximal SSI - Processed Foods. Also, in the proximal context participants made more arguments about the issue to resolve than in the distal context of SSI. The results of this study were argued to have implications for preparing effective SSI cases to be used in classroom instruction.

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156 The Theater Game "Teatro Fórum" as an Engagement Promoter of an Investigative Activity

Marcella Oliveira, Marcelo Motokane

Universidade de São Paulo, Ribeirão Preto, São Paulo, Brazil

Abstract

The objective of this research is to identify the engagement present in an investigative activity on bat biodiversity. Data were collected from the application of an investigative activity using the theatrical game "theater forum" as a resource. Conversational analyzes of the transcripts of discursive interactions were performed. The results showed that the theatrical game stimulated the students' productive disciplinary engagement and allowed the students to express their impressions, knowledge and doubts about different points of view, not limiting them to saying only what the teacher wanted to hear or to look for a single right answer.

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99 Enculturation of Pharmacy Students into Scientific Practices: A Closer Look into Affect and Conation in The Laboratory of Pharmaceutical Sciences

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Abstract

Student learning in the laboratory is multidimensional, as it encompasses psychomotor, cognitive, affective, conative, social, and epistemic domains. The many dimensions of learning

in this context lend themselves to a rich account of student experiences, but they are not equally represented in educational research and practice. The role of affect and conation has only recently gained a more prominent voice in the discourse of experimental work. In this paper, we are developing an assessment instrument that centres affect and conation in understanding epistemic practices associated with lab work. Different methods were used to investigate the problem, but in both labs, students were video- and audio-recorded during their lab work. Discourse analyses, both traditional microanalytic and epistemic network analysis were used. A survey instrument was developed and the students were interviewed. Provisional results from the discourse analysis substantiates at least five types of laboratory discourse, viz. procedural-psychomotor, conceptual, epistemic, instrumental, and affective discourse. It appears that for the physical chemistry lab, the conceptual discourse represents the weakest link compares to the other types of discourse. Data for the analytical chemistry lab is still being analysed but the higher inquiry level seems to generate more conceptual and epistemic discourse. The affective discourse is well represented in both labs, and it signifies a strong affinity towards effective collaboration, trust, and camaraderie, albeit sprinkled with curse words and a wide range of human emotions. The survey reveals that most students are very much willing to help each other, which triangulates findings from the discourse analysis. At least in the context of analytical chemistry lab, students are accustomed to collaborative problem solving and using evidence to support their arguments. Their motivational strategies indicate a large scope for personal goal settings beyond what is described in the manual.

Parallel Session - 7.11 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Athanasia Kokolaki

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227 MicroMundo: Experimental Project Fostering Contribution to Knowledge on Antimicrobial Resistance in Secondary School

Beatriz Robredo, Rosa Fernández-Fernández, Carmen Torres, Rubén Ladrera

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Abstract

Antimicrobial resistance (AMR) has become a serious global health threat. Education could play a decisive role, so the scope of innovative educational projects, such as MicroMundo, should be analysed. MicroMundo is a service-learning project for the exploration of microbial biodiversity in soils in search of new antibiotics. In order to evaluate the contribution of MicroMundo to the improvement of knowledge about AMR as well as the optimal age of the participants, an open questionnaire before and after the educational intervention and a satisfaction survey were carried out. Program instruction is subdivided in two phases starting in university and continuing through secondary school; 14 teachers (phase 1) and 137 students

from three educational levels (phase 2) participated. MicroMundo was successfully implemented, showing a statistically significant improvement in knowledge about antibiotics, resistance, health and environmental consequences, and possible measures to reverse the problem, at all educational levels. Therefore, it would be appropriate to carry out the program with students of general branches who have not yet opted for a scientific line. In addition, the satisfaction surveys also revealed a growing interest in research and science. For this reason, the implementation of MicroMundo is recommended as a training method for raising awareness about AMR and promoting scientific vocations.

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428 Designing SSI Lessons for Sustainability Education: Pre-Service Teachers' Pedagogical Content Knowledge

Tuba Stouthart, Dury Bayram-Jacobs, Jan van der Veen

Eindhoven University of Technology, Eindhoven, Netherlands

Abstract

The urge to transform educational practices towards teaching sustainability has been widely recognized in education. However, teachers experience difficulty in implementing education for sustainable development in their lessons. Even though the research in socioscientific issues-based instruction grows, the literature is limited regarding the use of socioscientific issues for teaching sustainability, and teachers' professional learning of socioscientific issues-based instruction as a means towards education for sustainable development. In this study, we aim to characterize STEM pre-service teachers' pedagogical content knowledge of designing a socioscientific issues-based lesson to teach sustainable development goals. The qualitative data were collected from five pre-service teachers and analyzed by Atlas.ti. Our findings show that we can capture all components of pedagogical content knowledge during the pre-service teachers' lesson design. The most emphasis is given to Instructional Strategies however, very little emphasis was given on Assessment.

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663 A Framework of Socio-Scientific Teaching Material on Japanese Golden Eagle for the Promotion of Biodiversity Conservation

Shiho Miyake[1], Naho Maeda[2], Risa Tsuboya[2], Takuya Tanaka[3]

[1]Kobe College, Nishinomiya, Hyogo, Japan. [2]Tennoji Zoo, Osaka, Osaka, Japan. [3]Kinki Environmental Partnership Office, Osaka, Osaka, Japan

Abstract

This study explores the fundamental elements required to establish a framework for socio-scientific teaching material that promotes to raise awareness of biodiversity conservation awareness among the Japanese. While most Japanese people know that human interventions such as controlling and maintaining the natural environment, industrialisation, or land development can cause biodiversity loss, they are unaware that disregarding nature is also detrimental to biodiversity. Japan is forest-rich with nearly 70% of

its land area covered by forests. Therefore, developing a theoretical framework for education that raises people's interest in forest maintenance as a socio-cultural issue and biodiversity conservation is essential. Based on information on forest environment and education, we formulate three fundamental elements—arousing sympathy from the public, developing a relationship between biodiversity conservation and forest maintenance, and finding an animal to use as a motif for a story of the teaching material. Specifically, this study also demonstrates that: 1) narrative nonfiction helps arouse sympathy from the public, 2) using a bio-symbiotic environment called Satoyama, the forest products industry may develop a relationship between biodiversity conservation and forest care, and 3) appearing Japanese Golden Eagle at Tennoji Zoo creates a parent-child narrative. Narration that speaks to the reader, such as in a parent-child conversation format, would motivate one to understand the complex context of biodiversity.

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709 Teaching Scenarios on Socioscientific Issues Developed by Pre-Service Primary Teachers

Athanasia Kokolaki, Dimitris Stavrou

University of Crete, Rethimno, Greece

Abstract

Socioscientific Issues (SSI) provide a solid framework for engaging students in meaningful and relevant scientific discourse. However, there is little empirical data regarding the way teachers design and implement SSI – based teaching scenarios. The present study focuses on the design of SSI teaching scenarios by six pre – service primary teachers for the negotiation of SSIs that emerge from contemporary scientific topics and particularly from the field of nanotechnology. The study was structured in three phases. Initially the participants got familiar with the scientific and the societal aspects of nanotechnology as well as the SSI – based teaching approach. Subsequently, they designed and developed the SSI teaching scenarios and finally, a small scale implementation of the teaching scenarios took place. The results give insights into the scientific and the societal aspects of SSIs integrated in the teaching scenarios as well as the learning objectives pre – service primary teachers associate with SSI – based teaching.

Parallel Session - 7.12 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Miriam Struchiner

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166 The Development of In-Service Elementary Teachers' Selection of Socioscientific Topics to Teach by Using Argumentative Activity Designs

Deniz Saribas[1], Ertan Cetinkaya[2]

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Abstract

Teachers should have ability to design teaching activities that enables their students to make evidence-based decisions on socioscientific issues (SSI). To achieve this aim, the current study investigated the development of in-service teachers' ability to select socioscientific topics to teach in elementary grades by designing argumentative activities on SSI in a graduate course. The participants of the study were seven graduate students who enrolled in "Teaching Socioscientific Issues" course of the Elementary Education Department of Institute of Graduate Studies in a private university in Turkey. The participants' argumentative activities were three-folds: (1) identifying a socioscientific topic, (2) listing claims and arguments about the topic, and (3) constructing arguments and providing evidence for the arguments about the topic. The participants completed each activity at the end of lecture in subsequent weeks. The first week included the introduction and discussion of SSI and ethical and/or moral aspects of SSI. The second week involved the discussion of what constitutes claims and arguments. In the third week, the teachers were introduced with the concepts of arguments and evidence. The instructor asked the teachers to identify a socioscientific topic to teach in elementary grade levels. They were free to change their topics in each activity. The topics, the claims, arguments, and evidence were discussed in the whole class after the teachers completed their activities. The results indicated the improvement in the participants' choice of SSI to teach and discuss in elementary grade levels through the identification of claims and arguments and providing evidence for their arguments.

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652 Science Teachers' Perceptions and Challenges of Participation and Action: A Case of 'Learning Science, the Gangnam Style' Project

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Abstract

'Participation and action,' a dimension of scientific literacy newly presented in the Korea Science Education Standard (KSES), is an innovative endeavour for future education. To be settled this in science education, it is essential to understand teachers' perceptions of it. This study aims to investigate the science teachers' perceptions and challenges of 'participation and action' when they develop and implement programs centered on 'participation and action.' To achieve this goal, we interviewed four teachers who took part in the 'Learning Science, the Gangnam Style' project to gain concrete examples. As a result, the science teachers' challenges in implementing the innovative programs stemmed from their traditional views, 'knowledge' is a priority. The teachers perceived that 'knowledge' and 'competence' are prerequisites for 'participation and action,' unlike what KSES suggested. This study has implications for finding specific ways to promote 'participation and action' in science education.

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804 Students' Local Rural Knowledge About Water: Today's Concerns for an Uncertain Future

Catalina Iturbe-Sarunic[1,2], Brant Miller[3], Cristian Merino[4,2]

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Abstract

Rural Science Education faces unique challenges as rural communities, and their water supply are affected by the ongoing climate crisis. To face this demanding task through science education, we propose to find a meeting point between Local Rural Knowledge about water and national standards to design Teaching and Learning Sequences that meet the needs of rural students and their communities. Rural communities have an inherent, intimate knowledge with their context and how water is used for a variety of purposes. For this study, students were tasked with creating illustrations related to water and the water cycle. A total of 10 students from four different rural schools located in various regions of southern Chile were interviewed to assess their understanding of local rural knowledge about water. Main findings are related to four themes: water sources/types, water problems/issues, local rural knowledge about water, and learning opportunities/challenges. Students identified 25 different water types and/or sources, 10 problems, 13 examples of Local Rural Knowledge and 11 learning opportunities. These findings led us to conclude that students have a diverse and rich set of knowledges related to rural water and that the Teaching and Learning Sequences to be co-designed must draw upon these findings to successfully implement a place-based educational alternative to the national curricula.

1031 Integrating Role Playing Game and Socioscientific Issues: Elementary School Students' Learning and Reflexions About Blood Donation

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Abstract

The aim of this study is to analyse the implementation of an educational Role Playing Game (RPG) about the theme of blood donation as a Socio-Scientific Issue in Science Education. The RPG was developed based on the ADDIE model. This study focus is the analysis of its implementation stage and its contributions to students' learning and reflexions. Twelve 8th grade elementary public school students in Rio de Janeiro, aged between 13 and 14 years old participated in the study, with the support of the Science teacher. The analysis was based on data collected from Discussion Group and Participant Observation. Data was transcribed and submitted to Content Analysis. It was verified that discussions in the simulated scenario of the RPG are capable of transforming the conception of scientific activity into a more real and human endeavor, in addition to promoting active and responsible citizenship, which is significant for scientific literacy and also for student education for sociopolitical action.

Parallel Session - 7.13 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Şirin Yılmaz

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595 The Effect of Cooperative Learning Using Socioscientific Issues on Learning Environment & Students' Achievement on Reaction Rate

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Abstract

This study aimed to examine the effect of cooperative learning and instructional context of socio-scientific issues on the learning environment and students' achievement on reaction rate. This study utilized a quasi-experiment posttest group-only design. The subject was three classes of high school students in Malang city and each class is treated using cooperative learning with socio-scientific issues, cooperative learning only, and conventional instruction, respectively. Data was collected using an achievement test on reaction rate and WIHIC questionnaire and then was analyzed using statistics. The result shows that there is a significant difference in average scores, achievements, or learning environment. The class taught using cooperative learning-SSI shows the highest scores compared with two other classes in both

variables. However, in detail, it is not the case for the teacher support aspect. This implies that the use of socio-scientific issues will enhance the students' achievement in chemistry knowledge and learning environment.

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688 Design Principles for Utilizing Formative Evaluation to Assess Socio-Scientific Issues Skills

Ilse Maessen, Dury Bayram-Jacobs, Marloes Hendrickx, Jan van der Veen, Jan Vermunt

Eindhoven University of Technology, Eindhoven, Netherlands

Abstract

Using formative evaluation (FE) in Socio-Scientific Issues (SSI)-based science lessons has a lot of potential as it can help teachers to assess students' skills developed in such lessons. Since limited research is available that combines these two areas, this study investigates how to utilize FE in SSI lessons in secondary science education by identifying the design principles for FE in SSI-based science lessons and collecting various perspectives on their relevance. By studying the literature on SSI education, assessment in SSI lessons, and FE we identified 27 subprinciples categorized in 7 main design principles for FE in SSI-based science lessons. Additional data on the relevance of the design principles were gathered through interviews with 24 science teachers, teacher educators, and researchers in education. The interviews were analyzed qualitatively. Initial findings show that teachers overall agree that the (sub)principles are relevant, but that they do not always know how to use them in class. Researchers' opinions on the relevance of (sub)principles vary and are closely related to their field of study. The teacher educators underline the relevance of most (sub)principles but acknowledge that teaching often requires more flexibility.

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906 The Nuclear Power Issues High School Students' Argumentation Around a Socio-Scientific Dilemma.

Noor Al Haj Ibrahem, Magnus Oskarsson

Mid Sweden University, Sundsvall, Sweden

Abstract

This study focuses on how students can argue and make decisions about socio-scientific issues that are relevant to their culture or region. The goal of this study is to present these dilemmas at the conference and propose incorporating decision-making about socio-scientific issues into the science education curriculum. The study explores students' skills in SSI argumentation and aims to clarify the relationship between values, knowledge and experiences in their SSI decision-making. Although all the students had access to the same information and agreed on the factual aspects of the issue, they came to different decisions, the difference depending on their background knowledge, values, and experiences. The result of the study found that students weighed the same information differently based on their core values and experiences.

The results showed that the use of SSI in science classrooms can promote students' decision-making skills, critical thinking and awareness of different factors that influence SSI issues.

1248 Examination of 8th Grade Students' Reasoning about Question Production: SSI Case

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Abstract

One of the main roles of Science Education is to increase students ' ability to think and ask questions. In this process, students should be directed to product and ask questions. The purpose of present study is to uncover students' reasoning about question production and reveal the students' definitions of deep question. We first determined two socioscientific contexts wherein there are ongoing debates in Turkey: base stations and hydroelectric power plants. Then we wrote scenarios about these contexts. We contacted the study with 21 8th grade students. We first presented these scenarios to the students and then asked them to write questions that would make them, when they read same scenario, deeply think. In other words, the students used the scenarios as premises and produced questions based on their Inferential Erotetic Logic (IEL). We used the erotetic conditions forwarded by Wisniewski (2013) for analyzing the each question's soundness produced by the students and used qualitative descriptive analysis to reveal the students' definitions of deep question. The results showed that no students' question meet all of the conditions of soundness. The questions of the students are problematic in terms of redundancy (Conditions 1 and 2). Another result, students were asked to produce deep questions and explain why the questions they produced were deep questions. The vast majority defined the deep question as a question that allows them to reach original conclusions, establish cause-and-effect relationship, make inferences. These results have the potential to open new possibilities for science education and question production studies. Incorporation of the nature of IEL and soundness of the questions into teacher education programs, for example, may produce promising outcomes.

Parallel Session - 7.14 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Kathy Cabe Trundle

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172 Culturally Responsive Methods in STEM Education

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Abstract

Remembering scientific information is a challenge for students of all ages due to the high intrinsic cognitive load arising whenever knowledge is based on and requires mutually dependent information that needs to be captured before an application in new situations can be reached. STEM education is impacted not only by the cognitive overload of the content but also by the demands of the social and economic transformations and much of the information is communicated without connection to context-specific inquiry. The purpose of this article is to present the results from the first phase of a research project that is aimed to develop culturally responsive pedagogy methods to facilitate the context-specific inquiry processes, accommodate the culturally influenced and diverse ways students learn, and help reduce the cognitive load in STEM education.

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604 Indonesian Preservice Teachers' Behaviours and Attitudes Related to Climate Change

Kathy Cabe Trundle[1], Rita Hagevik[2], Laura Wheeler[1], Rita Inderawati[3], Hartono Hartono[3], Elvan Sahin[4]

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Abstract

This research examined Indonesian preservice teachers' (n = 2,300) behaviours and attitudes related to climate change, including awareness, uncertainty beliefs, and values. Participants were enrolled in elementary, language arts/reading, languages, mathematics, science, social studies, or other education programs. We found that elementary and language arts education majors were more likely to hold an anthropocentric view of the environment, which correlates with climate denial. The values and worldviews individuals hold influence their willingness to accept climate change and to mitigate their behaviors. Thus, it is important that all teachers, including elementary and language arts teachers, have a clear understanding of climate change. These findings have implications for educational policy, professional development, outreach, curricula, and other educational materials.

1197 What Would a Sustainable City Look Like? Systems Thinking Activity in the Context of Waste Management

Burcu Güngör Cabbar

Balıkesir University, Balıkesir, Turkey

Abstract

There is no waste in nature. Ecosystems are in a sustainable order in a cyclical waste and product relationship. When it comes to the production and consumption behaviors of people, it is difficult to talk about the sustainability of the systems and a waste-free life. This activity is designed to realize the importance of the wastes created by the individual in the environment in which they live and the importance of the management of these wastes for sustainability, starting with their own behavior. With the series of student-centered activities, it is aimed to create action steps by discussing what the individual can do for waste reduction in a sustainable city at the end of the activity. Concepts such as sustainability, waste management and climate change are concepts that individuals of all ages should think about. The aim here is to realize the relationship between the part and the whole. With the systems thinking approach, it will be possible to realize the relations between the parts and the effect of these relations overall. With this activity, individuals are expected to examine the impact of parts of a city on the sustainability of the whole city.

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210 Environmental Science in Bhutanese Secondary Schools: Potential for Action Orientation

Kishore Mongar, Frances Quinn, Sue Elliott

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Abstract

Bhutan aspires to balance sustainable socioeconomic development with environmental conservation to achieve Gross National Happiness (GNH). There are apparent alignments between GNH and the principles of Education for Sustainable Development (ESD), but we recognise the role of the Bhutanese socio-cultural context for critically examining alignments with pervasive Western action-oriented ESD approaches. We present one aspect of a PhD study by the lead author that explored the implementation of Environmental Science (ES) in Bhutanese secondary schools. He examined stakeholders' perceptions about action-oriented approaches to teaching, drawing on qualitative and quantitative data from individual interviews with six principals, surveys and individual interviews with 14 teachers, surveys with 563 students and focus group interviews with 194 students. Findings indicated that the students participated in school-based activities such as waste management and cleaning, in compliance with school-based directives to alleviate problems, rather than as a consequence of their own agentic decisions. Principals, teachers and students valued the idea of taking environmental action in ES, especially waste management, primarily for solving ecological issues and promoting intergenerational equity rather than for developing of action-competence. There is potential

for leveraging existing school practices to enhance action-oriented approaches and, consequently, foster action-competence for the enhancement of GNH in Bhutan.

Parallel Session - 7.15 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Ragnhild Lyngved Staberg

533 International Molecular Biology Inquiry-Based Learning as a Catalyst for Future-Oriented Pedagogy Principles: A Case Study

Pirchia Tamar Waxman[1], Christine Girtain[2], Natalie Shalev[1], Dana Sachyani[1,3], Irit Sadeh[4], Michal Yaacobi[1], Samuel Ginsburgand[5], Galit Karadi[4], Shoshana Herman[1], Michal Zion[1]

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Abstract

The COVID-19 epidemic showed the world what we knew—the future is uncertain, and we must learn to deal with rapid changes and uncertainty. The education system plays an important role in preparing students to deal with uncertainty in the future. The Israel Ministry of Education presented a future-oriented pedagogy model. This model serves as a basis for building curriculum and teaching programs adapted to the 21st century and understanding the challenges the students will face in the future of rapid changes and uncertainty. The future-oriented pedagogy model includes six principles: personalisation, collaboration, informalisation, glocalisation, adaptivity, and self- integration. In this study, we present how open inquiry-based learning and international collaboration between teachers and students from different countries influence the expression of future-oriented pedagogy principles. The students participated in a learning process that is part of a unique Israeli teaching method called Bio-Inquiry on the Web, in which students from different classes work together. Students and teachers from Israel and New Jersey participated in this study. The collaborative inquiry project is called The Global STEM Wolbachia Project. Student participants used molecular biology methods to investigate the prevalence of a bacterium called Wolbachia in insects collected in Israel and New Jersey, USA. Teachers and students participated in an online questionnaire that was analysed qualitatively. The results indicate that this program facilitates the promotion of FOP principles.

793 Primary School Teachers' View of Critical Thinking in General and in Their Teaching Practices

Ragnhild Lyngved Staberg[1], Eli Munkebye[1], Eldri Scheie[2], Teresa Berglund[3], Maren Skjelstad Fredagsvik[1], Niklas Gericke[3]

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Abstract

Critical thinking (CT) has been highlighted as a key goal of education internationally and suggested to be an underlying basic competence in education for sustainable development to develop students into action competent individuals in complex environmental issues. However, there is a gap between policy and practice. Previous studies imply that teachers recognize the importance of CT, but many of them lack an understanding of what the concept entails, and they often feel too unprepared to teach CT. It is important to get insight into how teachers understand CT, as it is important for their teaching to promote students' CT. In this study we investigate which skills and dispositions teachers relate to when they reflect on CT. Using a reflexive thematic analysis of reflection notes and focus group interviews, we found that skills are more emphasized than dispositions by the teachers. It also seems that the teachers' notion of CT is close to the concept of criticality. There is a gap between how teachers describe CT in general and how it is described in relation to teaching. The findings suggest that dispositions, which include affective aspects, to a large extent seem excluded from the teaching of CT in primary school.

1027 Young People Envisioning Desired Futures Through Narratives of Change in Science Education

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Abstract

Fostering hope in a context of sustainability crisis depends not only upon cultivating awareness of the actual, socio-scientific issues at stake, but also requires providing opportunities and competences to create visions of how a more sustainable future may look like, and how the current social, technological, political, and economical systems involved in the crisis can be transformed accordingly. The ability to imagine a more sustainable future, however, has only recently begun to receive attention in the literatures on environmental and science education. The current study further advances this emerging area of research by investigating how upper secondary and high school students in science education describe their desired futures and pathways towards them. Drawing from data generated through a European coordination and action research project on science education for sustainability, we examine the narratives of change articulated in 187 stories written by students 14-18 years old on their ideal futures in Norway, Italy, Germany, and Austria. Our findings support the notion that, for students to learn

how to participate in developing action possibilities for sustainability, they need to make sense of existing narratives of change as well as become able to participate in co-creating new narratives, which integrate the learning of action possibilities with the systemic perspective for sustainability.

1282 A Case Study On Hydroelectric Power Plants (HES) As A Socio-Scientific Issue (SSI): Decision-Making Skills of Gifted Students

Saliha Öztürk

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Abstract

This is a study to reveal the reasons for the decisions of gifted students about the continuation or suspension of the construction of hydroelectric power plants, which is one of the socio-scientific issues. Three middle school students attending a science and art center in Istanbul participated in the study. The participants were 7th grade students. A case study was used as the research design. In the questionnaire, which is a data collection tool, after giving information about HEPPs and their positive and negative aspects, they were asked to write their own thoughts and justifications in detail about the continuation or stopping of the construction of HEPPs. In addition, all participants were interviewed and audio-recorded and transcribed by the researcher. The coding scheme used in data analysis was taken from Liu, Lin, and Tsai (2010). The forms of reasoning used by the students in making decisions about HEPPs were coded as ecological, socio-economic, and scientific-technological. In addition, ecological, socio-economic, scientific-technological, and ethical-aesthetic perspectives were identified from the interviews with the participants. Two of the participants decided that the construction of HEPPs should be stopped immediately, especially from an ecological point of view, while the other participant decided that the construction of HEPPs could continue if the necessary conditions were met from a socio-economic and scientific-technological point of view, such as making correct life water calculations and obtaining permission from the people of the region. Participants rarely expressed opinions on ethical-aesthetic aspects. It is estimated that this is due to the age group of the students.

Parallel Session - 7.16 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Jéssica Donelli Martin Santos

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35 Resilience, Collaboration and Agency: Galapagos Teachers Confronting the Disruption of COVID-19

Diego Roman[1], Mariana Castro[2], Cynthia Baeza[1]

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Abstract

In early March 2020, distance education replaced face-to-face instruction for the 7,270 children and 435 teachers in Galapagos, Ecuador. In addition, the Ecuadorian government implemented strict stay-at-home mandates to fight the COVID-19 pandemic. Rather than solely focusing on the effects of these measures and the devastating consequences of COVID-19, our study employed socio-cultural theory and a community-based approach to learn how Galapagueño teachers transformed instruction about the environment during these difficult times. Situating our analyses in the unequal learning situation that has historically occurred in Galapagos, we describe teachers' agency and reliance on professional networks to contextualize the national curriculum and identify ways to critically teach about local environmental topics through distance learning. Our study highlights the importance of educational efforts to build on the wealth of environmental and educational knowledge that exists in local communities.

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125 Identification of Native Animals and Willingness to Protect Them by Primary School Students

Oihana Barrutia[1], Oier Pedrera[1], Unai Ortega-Lasuen[2], José Ramón Díez[2]

[1]University of the Basque Country (UPV/EHU), Donostia-San Sebastián, Spain. [2]University of the Basque Country (UPV/EHU), Leioa, Spain

Abstract

Biodiversity education can be a lever of action to respond to the global crisis of biodiversity loss. In this work, we assess future generation's native species literacy and willingness to protect them. To this aim, we showed 6 to 11 years old children from northern Spain ten colour photos of different autochthonous animals from different taxa, including a common and a threatened species. Afterwards, we asked them to write down the animals' name and to select five of them to be protected. Results reveal that native species' knowledge is low, although it increases with age. In addition, children preferences to protect animals seem to be influenced by emotions, and not solely by their identification accuracy or by conservation priorities (e.g., species with a

threatened status). These findings point out the need to provide children the appropriate training addressing the species' features to be taken into account in order to ensure their preservation.

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163 The Effect of an Elective Environmental Science Course on Students' Knowledge and Risk Perceptions of Climate Change

Osman Aksit

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Abstract

Global climate change has become an alarming threat to our planet and previous studies showed that K-12 students as well as adults from various educational backgrounds do not have a conceptual understanding of the scientific concepts underlying climate change. However, most of the past studies regarding students' understanding of the climate change concepts were mainly conducted in developed countries. This study aimed to contribute to the limited literature on secondary students' knowledge and risk perception of climate change in developing countries. Specifically, this study investigated the effect of an elective environmental science (ES) course on a sample of Saudi Arabian high school students' knowledge of scientific concepts related to climate change (e.g., the greenhouse effect) as well as their risk perceptions of climate change. The results indicated that students' prior knowledge of scientific concepts related to climate change was very limited before participating in the ES course. Regarding the impact of the course, the results showed that students' content knowledge as well as risk perceptions of climate change increased significantly after attending the ES course. The findings of this study have implications for the teaching of scientific concepts about climate change in high schools in developing countries such as Saudi Arabia.

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326 "Didactic Game of Scientific Personalities for High School: "Those Behind Science"

Jéssica Donelli Martin Santos, Natália Sudan Parducci, Magda Medhat Pechliye

Universidade Presbiteriana Mackenzie (UPM), São Paulo, SP, Brazil

Abstract

Despite the many changes and revolutions that are taking place in the world, the teaching of basic sciences does not follow the same pace of change. Which ends up generating students and, as a consequence, a population with an archaic view of science and its collaborators—to the point of not knowing several scientists with notable contributions to society. With the aim of demystifying the systemic view of the students' scientists, a card game about science personalities was developed. The game was applied and evaluated through a questionnaire by 11 individuals aged between 18 and 25 years. The game developed a supportive and cooperative attitude that contributed to group work and improved the ability to build game

strategies based on reading, observation and dialogue More difficulty levels are planned to be developed, featuring personalities beyond those discussed here.

Parallel Session - 7.17 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Katrine Bergkvist Borch

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162 Informal Science Communication Meetings Shaped by Student Questions: Exploring Middle School Students' Questions on Space Science

Dilara Kara-Zorluoglu, Ülkü Seher Budak, Erenay Atay, Gaye D. Ceyhan

Bogazici University, İstanbul, Turkey

Abstract

The spread and acceptance of misinformation, as well as the denial of scientific claims and facts, are becoming more and more commonplace in the post-truth era. Increasing people's scientific literacy is a successful solution since scientifically literate citizens are expected to critically assess claims via evidence-based arguments (Barzilai & Chinn, 2020; Roberts, 2013). Engaging people with scientists is one efficient strategy to raise their scientific literacy (Roggatz et al., 2019; Woods-Townsend et al., 2016). A crucial component of scientific investigation is questioning (National Research Council, 1996; Baram-Tsabari et al., 2006). Science Communication meetings were organized for 7th-grade students for each unit in the science curriculum. In this study, students' questions in the solar system unit were investigated. The purpose of this study is to evaluate the number, focus, and quality of questions raised by students prior to these meetings. Questions from 7th-grade students were evaluated based on the categorization of Baram-Tsabari et al. (2006) which were the field of interest, the cognitive level of the question, and motivation. The field of interest was determined as physics/ solar system for this study. The finding of the study indicated that the most popular category of type of information requested was factual whereas the least popular one was a general request for information. Also, middle school students tend to ask questions in the properties category for the order of requested information. The results supported that analyzing students' questions can give teachers awareness of what students are interested in as well as what are the levels of these questions to provide any intervention during the class (Chin & Chia, 2004; Baram-Tsabari et al., 2006).

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585 Stages of the Professional Development of Mediators of Non-Formal Science Education Settings

Natália Candido Vendrasco, Ainoa Marzabal

Pontificia Universidad Católica de Chile, Santiago, Chile

Abstract

The mediation between the exhibition and the public is a fundamental factor in reaching the educational potential of non-formal science education settings. The mediation of guided tours is a complex task that requires the mobilisation of different types of knowledge by the mediators, which shapes their educational practices and, consequently, the visitors' experience. Therefore, this work sought to characterise the stages of the professional development of mediators of science centres and museums, aquariums, botanical gardens and zoos, identifying their professional knowledge evolution over their years of experience. A knowledge perception questionnaire was applied to 78 mediators from different Brazilian educational spaces to achieve this objective. It allowed recognising three stages of the professional development of mediators (insertion, stabilisation and diversification) and discussing their potential impact on the educational practices of mediators and, consequently, on visitors´ experience.

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706 Curatorial Design for Co-Creation of an Immersive Cultural Exhibition Experience

Gianna Savoie[1], Connie Svabo[2], Nancy Longnecker[1], Jennifer Cattermole[3], Steve Mills[4], Holger Regenbrecht[5], Susan Thorpe[6]

[1]Department of Science Communications, University of Otago, Dunedin, New Zealand. [2]Department of Mathematics and Computer Science, University of Southern Denmark, Odense, Denmark. [3]Department of Music, University of Otago, Dunedin, New Zealand. [4]Department of Computer Science, University of Otago, Dunedin, New Zealand. [5]Department of Information Science, University of Otago, Dunedin, New Zealand. [6]Hokotehi Moriori Trust, Rekohu, New Zealand

Abstract

In this presentation, we discuss theory in relation to curatorial design of an immersive, cultural exhibition by a transdisciplinary, multicultural exhibition team. The exhibition team is multicultural, with Moriori, Māori, New Zealand Pākehā (New Zealanders of European descent), Americans and Europeans. Moriori are an under-represented and misunderstood indigenous people of New Zealand and the focus of the exhibition is Moriori culture. The curatorial design is built on insights from science education, cultural education, science communication, computer science, music, archaeology, graphic design, and museum studies (synthesised in the notion of 'multiple mediated modes of visiting'). With Moriori and non-Moriori musicians, artists and others we will co-create an immersive exhibition. The immersive experience, artefacts and related components will be shared in schools as the NZ curriculum addresses its colonial history. A focus on cultural heritage can attract diverse and under-represented students to science education. By incorporating natural and cultural heritage into science education, students and other audiences can relate science to their own lives and communities. Engaging with indigenous knowledge can highlight contributions of indigenous cultures to science and technology. This can illustrate the relevance of science to indigenous students, contribute to science that is more inclusive and expand mainstream science education. Learning about the

science and technology of different cultures can build a deeper understanding of the diversity of human experience and lead to increased empathy.

726 Wicked Heritage in Informal Learning: Early Childhood Sensory Science Exhibitions

Katrine Bergkvist Borch[1], Connie Svabo[1], Stine Mariegaard[2], Katrine Bennedsen[1], Jonathan Gammeltoft[1], Eduardo Abrantes[1]

[1]University of Southern Denmark, Odense, Denmark. [2]University College Lillebælt, Odense, Denmark

Abstract

The World faces great environmental challenges in the form of "wicked" problems such as toxic waste, resource extractivism and collapsing ecosystems. This paper contributes to understanding how we can communicate this heritage to children through the exhibition medium. It is taken as a premise that understanding wicked problems depends on scientific understanding and that a good way to achieve this is through interdisciplinary STEM Education. Informal learning environments have a great potential in communicating scientific knowledge to the public, both through out of school visits and non-formal experiences. The aim of the paper is to address how to communicate toxic heritage and similar wicked legacies through the development of aesthetic and sensory experiences in informal learning environments. The paper draws on research from a pop-up STEM early childhood sensory science exhibition, located and developed at University of Southern Denmark in 2022. The design of the exhibition was research-based, drawing on theories of tidalectic curating, Conceptual PlayWorlds, STEM-pedagogy and early childhood science experience.

Parallel Session - 7.18 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Jingoo Kang

626 Equity-Focused Possibilities for New Interpretations of STEM Education

Lydia E Carol-Ann Burke, Sarah Lu, Ananya Mukherjee

University of Toronto, Toronto, Ontario, Canada

Abstract

The STEM acronym is now part of the Canadian vocabulary, but researchers and educators have not yet agreed upon the definition or purpose of STEM education. Much of the discourse associated with STEM in Canada derives from our geographic neighbours to the south (USA) who describe the value of STEM education as a mechanism for promoting economic

development and personal and/or national competitiveness. Despite the strength of voices describing STEM education as an economic imperative, there are also many who view STEM as a potential leveler, a means by which equity can be promoted in an education system that does not have a history of full inclusivity. The study described in this paper is a discourse analysis of a new provincial Science & Technology curriculum (released in 2022) that has included STEM education for the first time. The STEM discourse of the curriculum is explored alongside the discourses promoted by public school boards and equity-focused informal STEM education organizations in the region. The aim is to make more explicit the messaging presented by a range of formal and informal STEM education providers so that educators can be more intentional about deriving ways to connect and relate STEM learning, particularly for those learners whose positioning means that they might otherwise be marginalized within STEM education.

737 How Should Equality Be Defined?

Jaimie Miller-Friedmann[1], Apriel Hodari[2]

[1]University of Birmingham, Edgbaston, United Kingdom. [2]Eureka Scientific, Inc., Oakland, CA, USA

Abstract

Recent concerns about diversity and equality have motivated a range of responses across the world. Yet, differential uses of words like diversity and equality, particularly given variations in national populations, lead to confusion and distrust. In this paper, we argue for a shift from equality to equity, and an embrace of the complexity offered by differential national contexts. With a focus on fixing physics settings, rather than minoritized people, we suggest solutions that redistribute power to ensure physics settings are ones in which all people can thrive.

744 Obsessed and Depressed: Social Norms in University Physics

Amy Smith

Imperial College London, London, United Kingdom

Abstract

This study investigates perceptions of social norms for undergraduate physics students, and their influence on behaviour at a UK university. The study is part of an ongoing PhD research project using a mixed-method approach of focus groups and longitudinal questionnaires to investigate students experience on an undergraduate physics course. This paper discusses findings from two separate rounds of semi-structured focus groups, conducted across two years with different students from the same cohort. Data was analysed using thematic analysis grounded in the theory of planned behaviour. In the first round of focus groups nine students participated in the study, four women and five men. Competitiveness, obsession with the degree and having poor mental health were identified as key themes in the focus groups.

Physics was seen as the field in which these characteristics were comparatively normalised and almost celebrated within the department as a marker for success in physics. Some of the students described their efforts to break away from this norm and be seen as different through their involvement in extra-curricular activities or through forming study groups. However, for others the 'struggle' was seen as necessary and a rite of passage within physics. The implications for this study highlight there should be: (a) focused efforts to address how social norms play out within undergraduate physics courses and reinforce negative physics stereotypes, (b) a reevaluation of how we define success within physics undergraduate courses and (c) further research into the discourse around what it means to 'struggle' in physics.

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761 Measuring Students' Behavioral Patterns During Science Practices at Primary School: Gender Study

Jingoo Kang, Sakari Tolppanen, Anssi Salonen, Sari Havu-Nuutinen, Sini Kontkanen

University of Eastern Finland, Joensuu, Finland

Abstract

Participating in school science practice plays an important role in fostering young students' science interest, efficacy, identity, and aspiration. However, previous studies show that student participation in the practice is gendered as boys play more active roles while girls become passive during science practices at school. However, most of the studies used observation, and thus, there is a lack of tools to measure this behavior on a large scale and to examine the relationships between science practice, motivation, and background such as gender. Accordingly, we have developed a survey measuring primary school student science practice and piloted it with 75 4th-grade students in Finland. According to the results, our measurement indicates four behavioral patterns—Support, Lead, Hands-on, and Passive—and each pattern uniquely is related to science motivation. Also, we found no gender differences in their behavioral patterns and science motivations in grade 4 in Finland.

Parallel Session - 7.19 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Ainur Almukhambetova

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868 The Production of Non-Participation in the Primary Science Classroom

Ene Ernst Hoppe, Henriette Tolstrup Holmegaard

Department of Science Education, Copenhagen, Denmark

Abstract

This paper presents how non-participation is produced in the science primary classroom, utilizing the theoretical concepts of position and performance. Asking how non-participation looks like in science seems to be a simply question as it emerge as an antonym for participation often in the light as lack of motivation and interest. Though decades of research in science education has challenged such assumptions by emphasizing how certain kinds of groups are prevented from seeing themselves as science persons by the norms and practices in the classroom. These studies challenges this simplified relation between participation and non-participation in moving the perspective away from the individual to understand the norms of practices applied in science teaching. Thus, the aim of this study is to investigate how non-participation is produced: (a) what kinds of non-participations are performed and shaped in the science classroom practices and (b) are some of these performances of non-participation more dominant than others? (c) How are non-participation constrained or supported by ideas of femininity or masculinity? The study takes its departure in ethnographic fieldwork within two schools, where data was produced over one year by following pupils in 6th grade (12 years old). Three main theme appeared from a thematic analysis: The production of non-participation through 'exposure', being 'overlooked' and 'punishment'. In this paper, an empirical example is provided. The discussion argues how non-participation creates barriers for pupils to see themselves in science.

1150 The Place of Culture in Science Curriculums: A Literature Review

Fernanda Muniz dos Santos, Laísa Freire

Federal University Of Rio De Janeiro, Rio De Janeiro, Rio De Janeiro, Brazil

Abstract

This study aims to analyse how school curricula in Latin American countries consider cultural differences in their curriculum guidelines for national education. Although there are local experiences that take into account the cultural specificities of communities in content and pedagogical practices, it is assumed that different curricula are still being constructed, rather than curricula that include differences. The science curricula of 12 Latin American countries were analysed using the theory of Content Analysis (Bardin, 2011). The results indicate that there are few references to cultural differences in science curricula. It is concluded that natural science curricula are still permeated by the universalist conception of science, which places non-western and indigenous cultural knowledge as non-scientific knowledge that should be excluded from national school curricula. However, there are curricular movements that identify the differences that exist in the production of scientific knowledge, as in the case of Guatemala and countries where national curricula refer to different sciences, diets, health practices and astronomical understandings.

1217 Learning Within STEAM: Making and Doing Through Fostered Creativity in the 21st-Century Education

Nurgül Rodriguez del Ojo[1], Basak Helvaci Ozacar[2]

[1]University of Calgary, Calgary, Alberta, Canada. [2]University of Calgary, Calgary, Canada

Abstract

This research paper aims to depict the current narratives of creativity and innovation in STEAM education. It also presents our vision for the affordances and future of STEAM education. Even though many researchers limit the letter A in the STEAM acronym to a mere instrumentalization of arts, in this paper, we highlight that STEAM epistemologies are beyond the incorporation of arts. We asked one overarching research question: How can STEAM education be defined and described in pedagogical frameworks in the 21st century education? For this purpose, we conducted a literature review that comprises descriptive articles that include descriptions of STEAM activities and programs. These implementations are often more than theories, and pedagogical framework articles are those that propose models and frameworks. We present best practices of STEAM which are challenging neoliberal ideologies which are perpetuating hegemonic disciplinary practices intrinsic to STEM education. We propound that good science education should equip a critical lens through feminist theory and deconstructive approaches to accommodate equity for learners and educators in theory and practice.

1245 Exploring Rural and Small-Town Students STEM Pathways: Access to STEM-Related Learning Opportunities and STEM Career Aspirations

Ainur Almukhambetova

Nazarbayev University, Astana, Kazakhstan

Abstract

Several essential government initiatives have highlighted the urgent need for Kazakhstan to produce more highly qualified specialists to meet increasing STEM labor market demands. As there is a growing demand for a highly qualified STEM cadre, there is an increasing demand to attract and retain more students in STEM fields. Therefore, there is an urgent need to address the problem of specific demographic groups traditionally underrepresented in STEM, such as rural and small-town students. While the Government of Kazakhstan strives to address the issue of the lack of a talented STEM workforce by increasing the number of STEM-focused schools and providing more scholarships for students aspiring to get a STEM degree, less attention is still given to attracting rural and small-town students to STEM fields. Meanwhile, this demographic group of students who account for approximately 29 % of the student population in Kazakhstan, might face unique barriers that shape their educational and occupational pathways (Agger et al., 2018; Hillman & Bolland, 2019; Wells et al., 2019) in contrast to their urban counterparts. This qualitative study will focus on the STEM pathways of students from rural areas and small towns to analyze the opportunities and barriers they face in their STEM pathways and the factors that determine their STEM education and career aspirations.

Parallel Session - 7.20 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Pål Kvello

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14 Interrogating Climate Change Education Epistemology: Identifying Hindrances to Curriculum Development

Efrat Eilam

Victoria University, Melbourne, Victoria, Australia

Abstract

The aim of this conceptual paper is to interrogate current epistemological approaches for conceptualising climate change (CC) education, to critically point out ineffective approaches and false assumptions and to make practical suggestions that may be helpful in supporting the development of defensible and well-argued CC curriculum. The analysis begins by discussing the epistemological question: What is CC as a body of knowledge? It continues to examine CC education in the context of education for sustainable development (ESD), further focusing on tensions between ESD and the content-based curriculum. The analysis of CC literature reveals that CC as a body of knowledge is lacking a shared conceptualisation and shared terminology. Epistemological descriptors are offered for characterising CC and for ESD. CC is characterised as a discipline, whereas ESD is characterised as an agenda for solving the world's major challenges. This agenda is found to be unfit as a framework for CC curriculum development. Finally, it is recommended to include CC education in the curriculum, as a subject on its own right.

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116 Complexity of Practical Work in Science Curricula and Textbooks: Analysis of Recontextualizing Processes

Sílvia Ferreira[1,2], Leonor Saraiva[3]

[1]Instituto Politécnico de Setúbal, Escola Superior de Educação, Setúbal, Portugal. [2]UIDEF, Instituto de Educação, Universidade de Lisboa, Lisboa, Portugal. [3]Instituto Politécnico de Setúbal, Escola Superior de Educação, CIEF, Setúbal, Portugal

Abstract

This study analyses the complexity of practical work in Portuguese primary science curricula and textbooks. The level of complexity was appreciated by the level of conceptual demand of practical work as given by the complexity of scientific knowledge and cognitive skills and the relation between theory and practice. The recontextualizing processes that may have occurred in the textbooks were analysed by studying the relation between curriculum and textbooks. The study makes use of theories and concepts of the areas of psychology and sociology, particularly Bernstein's theory of pedagogic discourse. The results showed that curricular documents and

the six textbooks analysed evidence a tendency towards a low level of conceptual demand of practical work. The results also showed that recontextualization processes occurred in different directions and extensions according to the analysed dimensions. Although the analysis is focused on the Portuguese educational system, the methodological approach of this study can also be used to appreciate the level of complexity of practical work in other texts and educational contexts.

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717 Identifying Knowledge Important to Teach About the Nervous System in the Context of Secondary Biology and Science Education - a Delphi Study

Pål Kvello

Norwegian University of Science and Technology, Trondheim, Norway

Abstract

Teaching about the nervous system has become a challenging task in secondary biology and science education because of the fast development in the field of neuroscience. A major challenge is to determine what content to teach. Curricula goals are often too general to guide instruction, and information about the nervous system has become overwhelming and diverse with ubiquitous relevance in society. In addition, several misconceptions and myths are circulating in educational communities causing world-wide confusion as to what content is correct. To help teachers, textbook authors, and curricula developers in this challenging landscape of knowledge, the aim of the present study is to identify the expert view on what knowledge is important for understanding the nervous system in the context of secondary biology and science education. To accomplish this, we have conducted a content analysis of textbooks followed by a Delphi study of 15 experts in diverse but relevant fields. The results demonstrate six curriculum themes including gross anatomy and function, cell types and functional units, the nerve signal, connections between neurons, when nerve signals travel through networks of neurons, and plasticity in the nervous system, as well as 26 content principles organized in a coherent curriculum progression from general content to more specific content. Whereas some of the principles clarify and elaborate on traditional school biology knowledge, others add new knowledge generally being consistent with the curricula, both nationally and internationally. Importantly, the new framework for teaching about the nervous system presented here, meets the needs of society, as expressed by recent international policy frameworks of OECD and WHO, and it addresses common misconceptions about the brain. The study suggests an update of the content knowledge taught in secondary biology and science education.

1315 Open Schooling Networks With Connected Science Based on Care-Know-Do to Protect Cultural Heritage: A Cross-National Mixed Method Study

Alexandra Okada[1], Tony Sherborne[2], Silvar Ribeiro[3], Mihai Bizoi[4], Giorgos Panselinas[5]

[1]The Open University UK, Milton Keynes, Buckinhamshire, United Kingdom. [2]Mastery Science, London, London, United Kingdom. [3]Universidade do Estado da Bahia, Salvador, Bahia, Brazil. [4]Valahia university of Targoviste, Targoviste, Dâmbovița, Romania. [5]RDE, Heraclion, Crete, Greece

Abstract

Cross-national studies to foster scientifically literate generations based on inclusion, diversity and equity receive increased attention from governments. Various international initiatives in STEAM Education have been promoting knowledge exchange and capacity building among countries to tackle global challenges. However, research on cross-national research methods remains underexplored, with limitations related to cultural differences, rigour and relevance on data generation, integration and interpretation. This study explores a novel cross-national mixed-methods approach underpinned by a common framework CARE-KNOW-DO. It examines key benefits and challenges through a multi-language collection of open schooling artifacts, produced collaboratively in four countries within a cross-disciplinary context and multi-educational levels. The approach involved a cross-national team to locally adapt and cocreate curricula activities, reflective practice guidelines with coaching for teachers, science actions including a self-reported reflective instrument for students with open badges. Participants were 4,179 students, supported by teachers, scientists, and families. The first artefact used by students was rewilding to increase biodiversity towards cultural natural heritage protection in Romania, Greece, England, and Brazil. Findings show the significance of the cross-national mixed method implemented with rigor and relevance to identify and explore similarities and differences. Common aspects identified were positive attitudes towards science and the significant influence of teachers. Some nuances found in science capital were related to the relevance of science in students' lives, with the highest perceptions in Greece, Romania, and Brazil Northeast. In these countries, family and community-members involvement were prominent. Self-efficacy in science also differed, with higher percentages in Romania, Greece, the UK, compared with Brazil northeast and southeast. This study emphasizes cross-national mixed method instrumental in designing effective science education programs collaboratively that cater to the diverse needs and preferences of students worldwide.

Parallel Session - 7.21 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Moleboheng Ramulumo

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426 Examining the Relationship Between Science Evaluation and the Learning Environment: Benefits and Challenges of Different STEM Assessment Methods for Students' Well-Being

Maiken Westen Holm Svendsen

University of Southern Denmark, Odense, Denmark

Abstract

The aim of this prospect scoping literature review is to examine the influence of various forms of assessment in formal science education in Denmark, and how these assessments effect both learning environments and students' educational strategies. Additionally, the study will investigate the extent to which grades and various forms of assessment contribute to the overall well-being of students in an upper secondary school setting. This literature study is motivated by the decreasing welfare for young people in Denmark reported in a new study made by the University of Southern Denmark, on behalf of the Danish Government (Sundhedsstyrelsen, 2021) and inspired by the results and evaluations of the Danish project LabSTEM. This project has developed STEM education in Denmark, and it is pointing at the need of investigating evaluation practices in Danish STEM education. The study will employ a rigorous methodology, including the use of a comprehensive search of multiple academic databases, and a critical evaluation of the literature. The study aims at concluding findings concerning students' well-being in, or attitude towards, evaluation situation in science subjects. Additionally, the study will investigate the use of more authentic assessment forms, for an instance incorporating cultural heritage elements to provide an authentic and positive experience for students still evaluating he students' knowledge, skills, and competencies within this subject.

1013 Attitude Scale towards Skill-Based Science Questions

Basri Yurttaş, Nail İlhan, Sultan Şan

Inonu University, Malatya, Turkey

Abstract

The science curriculum of Türkiye was revised in 2018, taking into account the success in international exams such as PISA and TIMSS, and considering the new developments in education in the world. In addition, the secondary school to high school transition exam (LGS) has been changed and the questions of LGS have turned into a question style expressed as skill-based. Therefore, students' attitudes towards skill-based science questions are important for their success in this course. The aim of the study was to develop an attitude scale towards

skill-based science questions (AS-SSQ). For this purpose, the study was conducted with exploratory mixed research design. In the design, first qualitative and then quantitative method is used. In the qualitative part of the study, it is aimed at writing the items for the scale and creating the item pool. At this stage, it consists of literature review, taking student views through semi-structured interviews and conducting content analysis. After writing the items and making the necessary corrections, 5-point Likert type scale items were formed and then the scale was applied to 437 students in 5th, 6th, 7th and 8th grades. In the quantitative part, item analysis, exploratory factor analysis, correlation between factors and internal consistency coefficient were calculated. As a results, AS-SSQ was consisted of 20 items which were divided into four factors. The factors of the scale were named as enjoyment, anxiety, skill and confidence. As a result, the AS-SSQ was developed for secondary school students.

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223 Assessing Instructional Quality in Geography, Biology and History: A Cross-Subject Comparative Analysis

Natalie Bienert, Nina Scholten, Rainer Mehren

WWU Münster, Münster, Germany

Abstract

In the current discourse, the increasing necessity of a subject-specific assessment as a complement to a predominantly generic assessment of instructional quality is discussed. However, while there is a body of research regarding instructional quality of single subjects, not much is known about differences and similarities across biology, geography and history. Different kinds of operationalizing instructional quality and methodical differences in data collection further complicate comparability across subjects. Thus, this study takes an integrative perspective by cross-comparing the instructional quality of three neighbouring subjects to identify central levers for quality improvement, allowing a subject-targeted optimisation of instructional quality in the future and contributing to the discussion of generic and specific assessment. A data set containing n=2146 lesson observations in geography (n=679), biology (n=736) and history (n=734) obtained by the school evaluation in Saxony, Germany, comprises the basis of this secondary analysis. Using a standardised instrument, raters evaluated the lessons on a five-point Likert scale, with 1 being the lowest, 5 being the highest score. Overall, the instructional quality of all three subjects is above average (m=3,56). However, biology (m=3,61) outperforms both history and geography (each m=3,53). A factor analysis from a previous study of the authors revealed six subscales: classroom management, clarity and structure, consolidation, student orientation, content-based involvement, individualisation of the learning process. Concerning all subscales, the instructional quality in biology is higher than in the other subjects. However, there are some significant differences between the subjects (e.g., significantly higher content-based involvement in biology, m=3,41), but also major converging trends (e.g., little individualisation of the learning process across subjects, m=2,93). Consequently, the questions arise to what extent instructional quality, at least regarding some dimensions, actually is subject-specific and, if so, how existing measurement tools may need to

be further developed to adequately reflect subtleties of subject specificity.

842 Unlocking the Synergy of Science Literacy and Visual Acuity in Early Childhood Science Education

Moleboheng Ramulumo

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Abstract

Students in science-related subjects remain a critical issue in schools because students often find science complex. The use of visual representation is commonly proposed as instructional support to stimulate student engagement with complex science content. However, the literature posits that science students lack the visual literacy skills needed to facilitate meaningful learning of science. Based on the above discourse, the current research aimed to assist curriculum designers and educators in effectively using visual representations in early childhood science education. The research objective was to explore the relationship between visual and science literacy. The Cognitive Theory of Multimedia Learning formed the backbone of the research in order to explore the possibility of introducing science education in pre-primary school through visual literacy. The research used a quantitative approach. Data was collected through a content knowledge test from a purposively selected group of pre-primary school students from science, technology, engineering, and mathematics (STEM) and non-STEM schools. Data were collected quantitatively and analyzed by employing descriptive and inferential statistics. The results revealed that pre-primary school students from STEM schools have higher levels of science literacy. The findings suggest that earlier exposure to science education results in the acquisition of science literacy. However, inferential statistics found that visual literacy does not positively correlate with science literacy. The findings challenge the assumption that the introduction of science in early childhood fosters the development of visual literacy skills. Nonetheless, the study recommends that visual literacy be addressed and explicitly taught, as previous research has shown that the use of visual representations in science education contributes to science students' academic performance and cognitive skills development.

Parallel Session - 7.22 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Yukinori Utsumi

46 Reflective Experimenter: Fostering Experimental Skills through Videography

Lisa Stinken-Rösner

Bielefeld University, Bielefeld, Germany

Abstract

Science education is strongly characterized by experimentation. Integrating and conducting experiments in the science classroom requires pre-service teachers to develop pronounced experimental skills in various sub-areas. Within the framework of the project *[name of project]*, pre-service science teachers are given the opportunity to develop these in a professional environment without time and performance pressure by actively participating in the production of experimental videos. The iterative production process makes it possible to continuously reflect on one's own actions with regard to experimentation and to develop alternative actions. In guided interviews, the participants reported that the work in the project – even after the production of only a single video – enabled them to develop skills in experimentation that they had not acquired in traditional laboratory courses at the university up to that point.

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175 Formulation of Hypotheses Among Pre-Service Secondary Science Teachers in Scientific Inquiry: Investigating the Fall of a Dipterocarpus Seed

Yukinori Utsumi

Gifu University, Gifu, Japan

Abstract

Secondary science teachers need to support their students in scientific inquiry. However, pre-service science teachers do not take proper account of the importance of hypotheses in scientific inquiry. This study explored how pre-service science teachers formulate hypotheses and construct their own frameworks for solving problems seeking to decelerate the fall of a Dipterocarpus seed, which rotates and is borne on the wind when it blows. The findings indicated the process of problem-solving among the teachers. It unfolds as follows: the teachers observed phenomena and engaged in abductive reasoning using background knowledge. They then generated hypotheses and conducted trial experiments. They moved backward and forward between the ideas of their hypotheses and the experiments. Through this process, they identified which hypotheses they considered to be best. Ultimately, by this means, they converted their ideas into hypotheses and brought them into convergence.

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336 Pedagogical Formation Certificate Program from the Perspective of Teacher Candidates

Burak Çaylak

Hakkari University, Hakkari, Turkey

Abstract

This study aims to determine the perceptions of pre-service teachers who participated in the pedagogical formation certificate program regarding the sufficiency of pre-service education. 146 pre-service teachers participated in the research based on a descriptive survey study. The Teacher Perception Scale on the Sufficiency of Pre-Service Education (TPSSPsE) was used as a

data collection tool. The collected data were analyzed using a t-test and one-way analysis of variance. The findings of the study revealed differences in the perceptions of pre-service teachers in different departments (e.g., Turkish Language and Public Administration). However, when the perception is examined according to the faculty and gender variables, there is no difference among pre-service teachers in the perceptions of pre-service education.

Parallel Session - 7.23 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Elvan Sahin

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280 Research-Based Science Teacher Education: Views and Experiences from Norwegian Pre-Service Teachers

Ellen Henriksen

Oslo Metropolitan University, Oslo, Norway

Abstract

Research literature and curriculum documents prescribe that science teacher education should be research-based. This paper investigates the extent and the ways in which Norwegian pre-service teachers (PSTs) experience their education as being research-based. Findings suggest that PSTs experienced the content of the education as based on natural science as well as science education research to a great extent and that they engaged with and reflected on research to a somewhat smaller extent. Their interest in natural science and science education research was moderate, but they had relatively high expectations for research-based knowledge to be useful for them in their future teaching. Final-year PSTs expressed greater awareness and appreciation of research than their peers who were halfway through their education. Based on the findings I suggest that the role of research for developing professionally as a science teacher needs to be made explicit and discussed with PSTs throughout their education, progressively letting them engage more with research.

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674 "What's in the Bucket?" – a Case Study of How an Inquiry-Based Activity Can Give Student Teachers Experience With Argumentation in Science

Kirsti Marie Jegstad[1], Tonje Strat[1,2]

[1]OsloMet - Oslo Metropolitan University, Oslo, Norway. [2]NMBU - Norwegian University of Life Sciences, Ås, Norway

Abstract

Student teachers must become aware of their own argumentation skills in order to know how they can support their future pupils in argumentation. Therefore, we have created the inquiry-

based activity "What's in the bucket" to give student teachers experience with argumentation in science. In this activity, the student teachers were presented a bucket with unknown content and through the eight steps of the Argument-driven-inquiry model, they were supposed to develop scientific arguments of the bucket's content with claim, evidence, and reasoning. The aim of the study is to analyse data from the implementation of the activity to reveal in what ways the activity gives student teachers experience with the three knowledge domains. Data were collected through observation and audio-recordings of 20 student teachers in their fifth and final year, who worked in groups. The data were analysed with content analysis. The results revealed that the activity facilitates the student teachers to gain experience within all three domains: In the conceptual domain, the student teachers used their background knowledge to design and carry out data collection, and they discussed a number of topics and investigations related to the science. The epistemic domain emerged through the student teachers' discussions about what characterizes valid evidence and reasoning for their claims, and experiences with the review process of the report. The social domain was included since the student teachers had to communicate, argue, and discuss scientific knowledge at all steps. However, our results revealed a missing focus on reasoning and the argumentation session were of varying quality. Based on our results, we will discuss how the activity can include better scaffolding to improve the student teachers' arguments.

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755 Primary Pre-Service Teachers' Understanding of STEAM Education Through Lesson Planning

Marisa Correia[1,2], Maria Clara Martins[1]

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Abstract

A STEAM Program was implemented in teacher education to prepare primary pre-service teachers to develop lesson plans that take full advantage of the interdisciplinary connections between science and mathematics topics. In this paper we describe how primary pre-service teachers´ perspectives about STEAM pedagogy evolved through a science and mathematics methods course. Data collection consisted of pre-service teachers' assignments through STEM activities, interviews and questionnaires. Overall, findings support the notion that the program had a positive impact on pre-service teachers' understanding about STEAM approach.

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379 Investigating Middle School Students' Visions of Nature: A Survey Research

Gul Sena Varlioglu, Elvan Sahin, Ceren Baser Kanbak

Middle East Technical University, Ankara, Turkey

Abstract

Views of young people towards nature and human-nature relationship have been highlighted since it is indicated as significant for establishing environmental conservation and communication between organizations and public. Thus, the aim of the study is to identify middle school students' visions of nature including images of nature, values of nature, and images of human-nature relationship. Research was conducted with 903 middle school students in Hatay, Turkey. Using survey research, the data were collected by administration of Turkish adapted version Visions of Nature scale. Quantitative findings about images of nature suggested that most of the students view nature as wild nature. Regarding the results of values of nature, these students agreed that nature is important because it is God's entrustment to humans. Considering the human-nature relationship, the students feel relieved when they are in touch with nature and they have a viewpoint of that people's responsibility is protecting the nature. This study implied that it is required to provide educational activities in nature for expanding students' images of nature and their interaction with nature. Besides, an investigation of teachers' visions of nature for understanding how they influence students' values on nature and images regarding human-nature relationship can extend the interpretation of findings.

Parallel Session - 7.24 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Ditte Marie Pagaard

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256 Integration of Biology, Chemistry, and Physics Concepts when Analysing Socio-Scientific Issues by Science Teachers in Initial Training: A Study by Semantic Networks

Edith Herrera[1], Javier Pulgar[2]

[1]Universidad del Bio Bio, Chillán, Chile. [2]Universidad del Bio Bio, Concepción, Chile

Abstract

This research explores how science teachers in initial training (STIT) develop the pedagogical skills to design didactic sequences for a new course in the Chilean curriculum, Science for Citizenship. For this, STITs must establish core learning goals, considering the integration of scientific concepts and skills, and attitudes to address a socio-scientific issue (SSI) from a regional or global context. To design their learning sequences, they must analyse the ways in which biology, chemistry, and physics concepts relate in the SSI, in order to decide the set of concepts and skills to be developed by their students. After a systematic review, we select the topic of "mining wastes" to explore the ways in which STITs approach the integration of biology, chemistry and physics to address and further use SSIs in didactic sequences. We conducted a quantitative analysis through natural semantic networks based on a list with their answers.

Results point to serious formative difficulties for integrating physics concepts, pressure to promote attitudes within SSI, and insecurities when designing didactic sequences in the subject Science for Citizenship.

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920 Focusing on Language and Knowledge in Middle-School Science: What Do Children and Teachers Gain?

Suzanne Rønhøj Schjøtt, Dorte Maiken Lohse, Anna-Vera Meidell Sigsgaard, Ditte Marie Pagaard, Sonja Heinrich

University College Copenhagen, Copenhagen, Denmark

Abstract

This paper presents a small part of an ongoing research and educational development project integrating language and science in Danish middle-school classes. The aim is to make knowledge hidden in the science language visible to all students, especially second-language learners. In this part of the project, we followed a 6th-grade learning about the periodic table of the elements, where students were meant to make connections between the abstract topic and their material world. The paper shows how using the analytical tool semantic waves from The Legitimation Code Theory (LCT) enables the teacher to provide opportunities for all students, including second-language learners, to learn both science and related language features with meaningful progression. In dialogue with a functional model of language from systemic functional linguistics, SFL, semantic gravity is enacted as a tool for revealing differences between students' participation opportunities in various language-use situations, i.e., science activities. Finally, we will discuss our findings from the perspective of semantic waves, arguing that a student's understanding of science subjects depends on the teacher's ability to link common-sense knowledge with scientific knowledge. Thus, it is essential to have a waving movement going back and forth between different layers in the teachers' conversation with the students. Accordingly, we aim to create a methodology teachers can use in their preparation that integrates language and helps students access understanding in middle-school science.

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757 Semantic Waves and Attention to Language to Encourage Student Teachers' Development of Scientific Language and Science Understanding

Ditte Marie Pagaard, Dorte Maiken Lohse, Anna-Vera Meidell Sigsgaard, Sonja Henrich, Suzanne Schjøtt

University College Copenhagen, Copenhagen, Denmark

Abstract

This paper concentrates on how to integrate linguistic assessments and new perspectives in science classes in teacher education. The aim is to improve student teachers' understanding of the subject taught and to develop their professional language. Data for this paper comprises several final assessment assignments, collected among student teachers at a teacher training

program in Denmark. As one of the aims of teacher education is to prepare students for teaching, the paper also includes perspectives on how to increase opportunities among primary school students for participating in mainstream instruction. Student teachers must therefore learn to integrate complementary activities focusing both on scientific literacy and scientific content to help their future primary school students' progress both in terms of learning science and scientific language. The paper elucidates the importance of developing the student teachers' competences in linking professional knowledge to the subject they teach, as well as sharpening their awareness of the linguistic structures that apply in the language of science. It also demonstrates the centrality of merging these two elements as a central and an ongoing part of teaching science. We suggest, therefore, that teacher training programs must include teaching science literacy as a central part of teaching science subjects at. Finally, the paper highlights how differences in teacher-educators' disciplinary backgrounds, specialized in either a linguistic direction or a science discipline, made for fruitful discussions. The different angels from where the teacher educators approach the student teachers' assessments, gives us insights into some of the blind spots we have when attempting to create a wholistic teacher training program.

Parallel Session - 7.25 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Oscar R. Lozano

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140 Case Study of Building an Environmental Education Platform Through Cooperation Between the Science Museum, Schools, and City: An Attempt at Educators' Capacity Building

Toru Doi[1], Ryota Hirayama[2], Naohisa Nishihara[2]

[1]Yasuda Womens' University, Hiroshima City, Hiroshima prefecture, Japan. [2]Ogaki Museum of Natural Science and Experience Learning, Etajima City, Hiroshima prefecture, Japan

Abstract

ESD for 2030 is an international implementation framework ensuring education for sustainable development (ESD) by 2030 in five priority action areas (e.g. building educators' capacity) and six priority implementation areas (e.g. harnessing partnership and collaboration, and mobilising resources). It also considers it important for a country's stakeholders to work together to promote ESD and to identify the main factors in constructing a platform that they can use to share activities and experiences. Accordingly, this study investigated an environmental education programme in Etajima City, Hiroshima Prefecture, Japan. This seaside orienteering programme has realised many achievements over 10 years owing to a platform constructed through collaboration between the science museum, elementary schools, and the city. We determined that preparatory meetings, teachers' participation in the programme as

field staff, and the children's ambitious attitude during the programme helped build the educators' capacity. We also sought details of the programme, which is in the form of a fun game. Then, we clarified that the orienteering format can set up tasks that give children various perspectives, such as realising the richness of the sea and comparing the environmental indicators. They also gain the ability to use information at each point and learn. Details about this programme will provide a useful reference for building educators' capacity, harnessing partnerships and collaboration, and mobilising resources in other regions.

148 Disciplinary Professional Learning Community as a Resource for Lesson Design: A New Model

Stephanie Bismuth[1,2], Avraham Merzel[2]

[1]Weizmann Institute, Rehovot, Israel. [2]Hebrew University of Jerusalem, Jerusalem, Israel

Abstract

This study explored the characteristics of a disciplinary professional learning community (DPLC) of science and technology teachers in middle school and how these characteristics serve as resources for pedagogical design. We collected qualitative data through in-depth interviews with teachers and community's facilitator, and through observations of community meetings. We identified five main dimensions of the DPLC: the structural dimension; the content dimension; the social-affective dimension; the common production dimension and the meta-community dimension. The DPLC positively facilitated pedagogical design through the interactions between the identified characteristics and the personal and curricular resources used in lesson design, suggesting a new model for resources of pedagogical design.

224 Investigating Science Teachers' Pedagogical Content Knowledge (PCK) Related to Climate and Weather

Kübra Sağbilge[1], Ceren Öztekin[2]

[1]Private Bornova Birikim Middle School, İzmir, Turkey. [2]Middle East Technical University, Ankara, Turkey

Abstract

This study examined experienced science teachers' pedagogical content knowledge (PCK) regarding climate and weather. Data were collected by means of PCK pre-post interviews, classroom observation and teacher documents, and analysed by deductive and inductive coding. Findings showed that science teachers were knowledgeable about curriculum objectives, horizontal and vertical relations and the place of the topic in the curriculum. They were able to express students' prerequisite knowledge, but they had difficulty in expressing students' learning difficulties and misconceptions, and have tendency to apply traditional instructional strategies and assessment methods into their teaching. Overall findings imply that a professional development program should be designed to improve teachers' PCK in the context of the climate and weather.

1295 School Internationalisation Through European Projects and Their Impact on In-Service Teacher Training Programmes: A Case Study in Spain

Oscar R. Lozano[1,2], Amelia R. Granda-Piñan[3,2], Elena Thibaut-Tadeo[1,2]

[1]Conselleria Educación CEFIRE CTEM, Valencia, Comunitat Valenciana, Spain. [2]Universitat de Valencia, Valencia, Comunitat Valenciana, Spain. [3]Conselleria de Educacion CEFIRE CTEM, Valencia, Comunitat Valenciana, Spain

Abstract

The internationalisation of schools by participating in European projects, such as the Erasmus+ programme, is a key element in teacher training. Different studies have shown the impact of these practices on different aspects of the daily life of schools. This study deals with the transposition of the implementation of Erasmus projects into in-service teacher training plans and its results in the case of the Valencian Community (Spain). Specifically, it presents the results of the development of six European projects (five from KA201 and one from KA3) and their impact on STEM teacher training. CEFIRE CTEM, an active participant in these projects, is a teacher training centre of the Valencian regional government focused on career development and lifelong learning for STEM teachers in the Valencian Community. Its participation in these projects has led to the design and implementation of numerous training courses related to the different topics addressed in them, from educational inclusion through 3D printing to the development of methodologies aimed at improving the mathematical competence of early childhood education teachers. The excellent reception of these courses and their positive final evaluation by the participating teachers shows an effective way of transferring the results obtained in educational innovation and research associated with the Erasmus+ programme into the school education teacher training programmes.

Parallel Session - 7.26 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Fernanda Franzolin

1044 Investigation of Teacher Self-Regulation of In-Service Science Teachers by Gender

Fatma AY[1], Cansel Kadioğlu Akbulut[2]

[1]23 Temmuz Middle School, Erzurum, Turkey. [2]Tokat Gaziosmanpasa University, Tokat, Turkey

Abstract

This study aims to examine teacher self-regulation of in-service science teachers by gender. For this purpose, a descriptive survey study was carried out with 445 science teachers, 283 females

and 162 males, working in different cities throughout Türkiye. The Teacher Self-Regulation Scale was used as a data collection tool. The instrument consisted of nine dimensions: namely, goal setting, intrinsic interest, performance goal orientation, mastery goal orientation, self-instruction, emotional control, self-evaluation, self-reaction, and help-seeking. Participants from different regions of Türkiye were reached online via Google forms in the spring term of the 2021-2022 academic year. In the data analysis, descriptive statistics were calculated to determine the participants' teacher self-regulation level. Then, multivariate analysis of variance (MANOVA) was used to investigate the difference in teacher self-regulation by gender. With the results of the descriptive statistics calculated for the nine dimensions of the scale, it was seen that all the participants considered themselves at a very high level in the dimensions of goal setting, intrinsic interest, self-instruction, emotional control, self-evaluation, self-reaction, and help-seeking. On the other hand, it was found that they considered themselves at a high level in terms of mastery goal orientation and a low level in terms of performance goal orientation. When examining whether teacher self-regulation differed in terms of gender, it was seen that there was a significant difference between the groups in favor of males in the dimension of self-instruction and favor of females in the dimensions of self-evaluation, self-reaction, and help-seeking. It is noteworthy that few studies in the literature examine teacher self-regulation of in-service science teachers. It is recommended that more studies can be conducted on this subject to compare the results of the present study.

1100 Imagining Is Not Thought Experimenting

José Manuel Ruvalcaba Cervantes

Cinvestav, Monterrey, Nuevo León, Mexico

Abstract

Work on thought experiments with secondary school physics teachers suggests that the solutions or conclusions that teachers obtain show fragmented knowledge and disintegrated theoretical and experiential knowledge. Here we argue that teachers are unfamiliar with thought experimentation and that their knowledge is integrated. To do this, we answer what are the teachers' mental actions when experimenting in thought. Through a qualitative study, using think-aloud and retrospective interviews, in which teachers performed thought experiments on free fall. We found that teachers manifest various actions that show that they do not carry out thought experiments per se. However, teachers use integrated theoretical and sensory information in mental actions. The limitations of our findings correspond to an unrepresentative sample, to the use of classic and familiar thought experiments for the participants with a particular content. However, we provide elements to systematically study and analyse the thought experimentation beyond the variation and simulation constantly alluded to in the literature.

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608 Correspondences of *Habitus* With the Socialization Processes of Science Teachers in Brazil

Gabriel Lanzillotta, Mauricio Pietrocola

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Abstract

The practice of the science teacher is a complex, contextual and situational process, where several instances "claim" to be the legitimate holders of the "true" teacher formation. However, teacher education does not begin at the university, much less has its culmination in classroom practice, but several spaces directly influence the socialization of ways of acting. We know very little about the specific arrangements and strategies on teacher socialization process and their relation to practices inside and outside schools. The aim of this work was to investigate the relationship between the habitus of science teachers of basic education in Brazil with their socialization processes throughout their personal life, social, academic and professional trajectory. The theory of Pierre Bourdieu was used to make a search cut among science teachers of basic education in order to develop a mixed methods (qualitative-quantitative) research based on data collection throughout a questionnaire and a semi-structured interview. The data analyzed was made by the Multiple Correspondence Analysis (MCA). The results showed two different profiles of the teachers' habitus, marked by gender differences and by the spaces of socialization. We concluded that the teacher formation needs to take into account the different trajectories and provide spaces where the science teacher can perform a reflective process so that these issues appear and gain relevance.

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591 Brazilian Teachers' Visual Representations of Biological Evolution

Carolina Maria Boccuzzi Santana[1], João Paulo Reis Soares[1], Graça S. Carvalho[2], Fernanda Franzolin[1]

[1]Federal University of ABC, Santo André, São Paulo, Brazil. [2]University of Minho, Braga, Braga, Portugal

Abstract

Visual models are important to facilitate the understanding of complex phenomena. In biology education, cladograms are relevant to help students understand organisms' common ancestry. However, this representation does not often occur in school practices. Considering the teachers' importance to science education, it is relevant to understand how they represent evolution. Therefore, this paper aims to understand the visual representations that Brazilian teachers build when thinking about evolution. Thus, 48 Brazilian teachers, who participated in an online teachers' professional development course, were asked to build a visual representation of the evolution of a list of organisms. The images were categorised. Teachers built images that were similar to cladograms (24 occurrences); groups of organisms (9); linear representations about evolution (8); or other types of representations (7). Thus, an expressive number of teachers did not think about cladograms to represent biological evolution.

Therefore, it is important to reinforce the work with cladograms in Science and Biology teacher education, allowing its use in the classroom.

Parallel Session - 7.27 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Ergi Bufasi

566 Exploring Pre- and In-Service Science Teachers' Green Chemistry and Sustainability Awareness and Their Attitudes Towards Environmental Education in Israel

Ahmad Basheer[1], Ayshi Sindiani[1], Muhamad Hugerat[1], Ozcan Gulacar[2], Ingo Eilks[3]

[1]The Academic Arab College for Education in Israel- Haifa, Haifa, Israel. [2]Department of Chemistry, University of California, Davis, California, USA. [3]Department of Biology and Chemistry, Institute for Science Education (IDN) - Chemistry Education, University of Bremen, Bremen, Germany

Abstract

In this study, 271 pre- and in-service science teachers in Israel were surveyed on their level of awareness about green chemistry and sustainability, as well as attitudes toward environmental education. Of the total participants, 123 were in-service science teachers with different seniority levels teaching in elementary, middle, and high schools. The remaining participants were teacher candidates studying at different institutions. The main source of the data was derived from a 34-item questionnaire that assessed teachers' awareness of green chemistry and sustainability and attitudes toward environmental education. The findings illustrated that the teachers' sustainability and green chemistry awareness was low in general, although their views on environmental education were mostly positive. In-service science teachers were found to have more knowledge about green chemistry and sustainability than pre-service science teachers. Notably, in-service science teachers with more than 10 years of teaching experience were found to have more knowledge than those who have less experience. Teaching implications and possible future studies were presented as well.

745 Primary Teachers' Adaptive Expertise in Interdisciplinary Mathematics and Science

Jan van Driel[1], Amanda Berry[2], Lihua Xu[3], Colleen Vale[2], Wanty Widjaja[3], Joseph Ferguson[3], Gahyoung Kim[2]

[1]The University of Melbourne, Melbourne, Australia. [2]Monash University, Melbourne, Australia. [3]Deakin University, Melbourne, Australia

Abstract

Although the benefits of interdisciplinary approaches to teaching mathematics and science are well documented, these approaches are challenging for teachers. This paper is based on the premise that adaptive expertise, as a critical component of quality teaching, is required to teach interdisciplinary mathematics and science in ways that effectively enhance student learning and interest. Specifically, this paper explores how adaptive expertise can be characterised among primary teachers through classroom innovations focusing on interdisciplinary mathematics and science learning. An innovative lesson sequence was co-planned and co-taught by teams of teachers in two Australian primary schools. Data collection included 360 video recordings of the lessons and teacher reflections. Striking differences between the two teams were observed in terms of teachers' adaptive expertise, related to differences in competence and confidence. Implications include how adaptive expertise might be scaffolded for different teachers.

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747 The Perceived Effects of a Science Teacher Astronomy Camp for Activating Education and Training to the "Green Deal" Transition

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[1]Trakya University, Edirne, Turkey. [2]Diyarbakır Provincial Directorate of National Education, Diyarbakır, Turkey

Abstract

To make the transition to the "Green Deal," there must be a clear understanding of how the initiative can be infused to learning and teaching, as well as effective strategies can be developed for involving students and teachers in the initiative's training. This study focused on the value of science teacher astronomy camps, one of the increasing opportunities for teacher training, in activating education and training for transition. 30 campers participated in this qualitative study, and data sources included reflective papers, qualitative ideas presented on a semantic differentiation form, and activity evaluation forms. The results of this study provide supporting evidence that teacher astronomy camps can be effective environments for provoking the "Green Deal" transition. The current study, therefore, contributes to a growing body of evidence suggesting that the initiative can touch on astronomy teaching and learning in several ways.

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892 Transforming the Teaching and Learning of Mathematics and Science in Primary Schools Through Spatial Thinking Professional Development

Ergi Bufasi, Ildze Čakāne, Dace Namsone, Inese Dudareva

University of Latvia, The Interdisciplinary Center of Educational Innovations, Riga, Latvia

Abstract

The teacher is no longer an instructor who teaches rules and procedures and corrects relevant tasks, but rather a facilitator of information, mathematical thinking, and reasoning abilities.

Several longitudinal studies demonstrate that strong spatial abilities are associated with increased interest, performance, and creativity in STEM (Science, Technology, Engineering, and Mathematics) fields. However, spatial reasoning is often absent from present mathematics curricula, and teachers avoid spatial activities due to their weakness or fear of spatial tasks. The current study is based on a larger professional development project designed to support teachers in learning how to teach thinking skills, spatial thinking, and geometry concurrently within the mathematics and science curriculum. Our findings indicate that the adaptations were successful in improving teachers' understanding of spatial thinking and its importance in math and science, as well as their commitment to including more spatial activities in the classroom and enhancing collaborative practices among teachers. Finally, we discuss the theoretical implications of our findings.

Parallel Session - 7.28 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Carrie Swanson

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374 Multi-Dimensional Teacher Implementation and Collaborative Learning Practices on Students Academic, Social and Emotional Learning

I-Chien Chen, Selin Akgun

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Abstract

Current reforms conceptualize science classrooms as spaces where students engage in the "doing" of science or "using" of knowledge to problem solve. This type of learning involves student collaboration. Teachers vary in their capacity to implement collaborative learning. This study uses exploratory mixed method analysis and a multilevel model to unpack teachers' implementation in facilitating collaborative learning in 59 third grade science classrooms. Using 202 classroom observations among 40 teachers, and approximately 1000 students' academic, social and emotional learning performance, this study aims to understand the developmental patterns of teacher implementation in collaborative learning over time and how those patterns affect students' academic, social and emotional learning.

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558 How do Educators Engage Preschoolers in STEM-Related Learning Experiences?

Christine Tippett[1], Todd Milford[2], Roxana Yanez Gonzalez[1]

[1]University of Ottawa, Ottawa, ON, Canada. [2]University of Victoria, Victoria, BC, Canada

Abstract

Despite the ongoing attention afforded to kindergarten to post-secondary STEM education, relatively little research attention has been directed to STEM with preschool children and related learning experiences. However, preschool children are naturally inclined towards STEM. Our research is grounded on the theoretical frameworks of social constructivism where preschoolers are active in constructing their own knowledge and play-based learning, where young children are free to engage in learning experiences arising from their interests. In this presentation, we report on our observations of 5 early childhood educators and the 25 preschoolers in their care. During each of 27 visits to a childcare centre, we observed the educators and preschoolers for approximately 45 minutes in a variety of settings (e.g., indoors, outdoors, during transitions between spaces), looking for episodes of STEM. We found three categories of educator interactions, but also found that many STEM episodes did not include educator interactions. We expect that our findings will be of use to researchers and educators who are interested in how socially constructed and play-based learning experiences can support STEM education with preschoolers.

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630 Students' Perceptions of their STEM Learning Environment

Nicole Fairhurst, Rekha Koul, Rachel Sheffield

Curtin University, Perth, WA, Australia

Abstract

Australia's economic need for innovation has led to Science, Technology, Engineering and Mathematics (STEM) education becoming an essential investment for the future. In this study, a mixed-methods approach utilising a pre-validated quantitative questionnaire, and qualitative semi-structured focus groups were conducted with students across four Year 5 classrooms. The students provided their perceptions of their STEM Learning Environment and their interactions with their teacher to determine factors influencing their engagement to pursue these disciplines. The questionnaire comprised of scales from three different instruments: the Classroom Emotional Climate, Test of Science Related Attitudes and Questionnaire on Teacher Interaction. Several key findings were explored through the student responses, including Student Freedom, Peer Collaboration, Problem Solving, Communication, Time, and Preferred Environments. 33 out of possible 40 correlations between scales were indicated as being statistically significant; however, the Eta2 scores were considered low between 0.12 – 0.37. Overall, the students expressed positive perceptions about their STEM Learning Environment, and Student Freedom, Peer Collaboration, Problem Solving, Communication and Time appear to impact their perceptions of STEM education. Additionally, three focus groups were conducted with a total of twelve students, who made suggestions for improving STEM Learning Environments. The implications from this research project include the importance of considering student perceptions when measuring the quality of STEM Learning Environments, and how facets of these environments impact student attitudes towards STEM.

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641 Exploring How the Figured Worlds of Primary Schools Impacts the Teaching of Science

Carrie Swanson

Auckland University of Auckland, Auckland, Auckland, New Zealand

Abstract

International and national studies highlight a decline in student interest and understanding of science in primary schools. One significant factor that can impact the teaching and learning of science is how science is viewed and supported in the school culture. This interpretative study utilised semi-structured interviews to explore the views of five participants in senior leadership on how science was structured and taught at their primary school. Figured worlds (Holland et al., 1998) was used as a conceptual framework for this study, and data was analysed to highlight the actors of science, and the actions and outcomes valued by senior leadership. The figured worlds of the schools, which incorporated both physical and sociocultural aspects, were shaped by the philosophical perspectives of senior management on what science is, how science teaching should be prioritised, including access to resources and professional development.

Parallel Session - 7.29 (Oral Presentations)

14:00 - 15:30 Thursday, 31st August, 2023

Chair: Veli-Matti Vesterinen

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73 Capturing and Developing Science Teachers' Pedagogical Content Knowledge Using Video Reflection and Content Representation: In the Framework of the Refined Consensus Model

Annika Forsler[1], Pernilla Nilsson[1], Susanne Walan[2]

[1]Halmstad University, Halmstad, Sweden. [2]Karlstad University, Karlstad, Sweden

Abstract

Science education researchers have, over time, developed a refined understanding of the structure of science teachers' pedagogical content knowledge (PCK). This qualitative case study demonstrates that a combination of tools for reflection can support science teachers in capturing and developing PCK. Further, the study provides example of how the Refined Consensus Model (RCM) can be used as an analytical framework for capturing and developing science teachers´ PCK.

1096 Writing Fiction to Expose Learning: An Adventure with Genetics

José Manuel Ruvalcaba Cervantes, Irwing David Vásquez Cerqueda

Cinvestav, Monterrey, Nuevo León, Mexico

Abstract

In science education, it is common to find examples that use narratives and storytelling to mediate science learning. Usually, the texts are read and analysed. Our work has another focus, science fiction writing to communicate learnings in science classes. We seek to answer the question of how high school students communicate their learning about genetic inheritance by writing science fiction short stories. To answer, we applied a workshop in which the students wrote science fiction short stories. The short story has to describe what appearance and the evolutionary changes humanity could experience. We suggested that writings use at least the keywords: phenotype, genotype, dominant and recessive allele. The workshop has three phases, and we handed out two orientation cards: 1) to recover previous learning and 2) to have at hand the structure of a short story. The results indicate that the writing of the short stories does not show what the students have learned. Instead of finding precise use of the keywords considered, students narrated catastrophic and dystopian scenarios in which humanity would have other characteristics. The results also reveal the potential and probable relevance of the personal construction of conceptual orientations to mention keywords. We hope that this work provides empirical elements to discuss, in a broader project, the relationship between scientific imagination and scientific thinking skills.

1153 Drawing Comics to Deepen Our Understanding About Students' Images of Science and Scientists

Veli-Matti Vesterinen[1,2], Jaakko Lamminpää[3,2]

[1]University of Helsinki, Helsinki, Finland. [2]University of Turku, Turku, Finland. [3]Turku University of Applied Sciences, Turku, Finland

Abstract

For more than 50 years, drawing tasks have been used to study students' stereotypes about of science and scientists. In recent years the focus of this research has shifted towards students' conceptions of science as an activity and emotions associated with science, which seem to play a central role in the development of interest towards science. This study combines drawing analysis carried out using a recently developed Draw-A-Science-Comic Test (DAST) with survey data on students' interest and self-efficacy in science. The data was collected from 130 students aged 12 to 13. The results show, that the students the students with higher self-efficacy and interest in science were more likely to depict various elements of inquiry as well as social aspects of scientific practice. Students with high self-efficacy were also more likely to depict scientists experiencing positive emotions, such as happiness, excitement, wonder and curiosity.

Parallel Session - 8.1 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Angelika Bernsteiner

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152 The Effect of Virtual Laboratory Applications with Brain-Based Learning Approach on Motivation

Ceyda Balcı Çömez, Mehtap Yıldırım

Marmara University, Istanbul, Turkey

Abstract

In this study, the effects of virtual laboratory applications with brain-based learning and traditional laboratory applications with brain-based learning on the motivation of students in teaching the Light unit were investigated. In the study, two groups were preferred and one of the quantitative research designs, pre-test post-test experimental design without control group was used (Sönmez and Alacapınar, 2013). The study group consists of 2 branches and 40 students selected by appropriate sampling, studying in the 7th grade of a secondary school in the Sultangazi district of Istanbul in the 2021-2022 academic year. Virtual laboratory applications performed with brain-based learning in the first group (BBLV) and traditional laboratory applications performed with brain-based learning in the second group (BBLT) were used. Virtual lab applications Go-Lab. platform, traditional laboratory applications were carried out in real materials in a laboratory environment. As a data collection tool, the Motivation for Science Learning scale developed by Dede and Yaman (2006) was applied as a pre-test and post-test. As a result of the analysis, it was determined that virtual laboratory applications with brain-based learning were statistically more effective than traditional laboratory applications in increasing the motivation of students.

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203 Teaching Nanotechnology Concepts through the Use of Digital Technology to Early-Primary School Children

Pandora Dorouka, Michail Kalogiannakis

University of Crete, Rethymno, Greece

Abstract

Although today's societies have largely been capitalized on the existing technological advances, the domain is still in its infancy, rendering an imperative need of research of novel methodologies by which an even wider range of fields can benefit from. This research has the objective to evaluate the possibilities offered in order to improve the existing teaching procedures through computer desktops and smart mobile devices. Nanoscience and Nanotechnology (NST) education is a new interdisciplinary field that promises to address global challenges and it could immensely benefit from the applications of technology. It is and it

should be viewed as an urgent priority so that the numbers of specialized human resources rise to the point that are capable of sustaining a solid and prosperous NST-related industry. In order for that to be achieved, it is mandatory to popularize the existing NST concepts to the younger generations and specifically to children. The focus of this dissertation is to compare the impact and effectiveness of alternative experiential teaching on early-primary school children of the domain of the interdisciplinary field of NST against its more contemporary alternatives that employ the use of computers and smart mobile devices. Through the use of software applications in the form of digital games, the context of this research is to expose groups of young children to elements of NST concepts and examine the learning outcomes. The three-step research process aimed to measure the effectiveness of two different digital technologies (computers and tablets) at an introductory level on children's understanding of Nanotechnology concepts. 150 second-grade children were divided into two experimental groups and a control group. Children's knowledge about size was assessed with the Nanotechnology Elementary Knowledge Assessment Test (TENANO). The findings revealed that the two experimental groups significantly outperformed the post-test control group, with the dominant tablet group.

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822 Using Augmented Reality and Simulations to Support Learning of Fundamental Electrical Concepts

Florian Frank, Christoph Stolzenberger, Thomas Trefzger

University of Würzburg, Würzburg, Germany

Abstract

Secondary school students struggle to fully understand fundamental electrical concepts such as the relation and difference between current and voltage. According to multimedia learning theories, the use of augmented reality applications or simulations can support students in this process by presenting all the necessary information together at the same time and in the same place. Multimedia technology can support students learning about electricity in two cases: the learning of didactic models and the collection and presentation of data in experiments. For these purposes, the application "PUMA : Spannungslabor" was developed. The application visualizes didactic analogies for electricity, either using Augmented Reality to place a digital representation atop a real-world circuit or using a simulation to place it atop a fully 3D computer modeled circuit. The close proximity of and real time interaction between the didactic analogy and the circuit enables the students to link the analogy and the fundamental electrical concepts more easily. This leads to a deeper understanding. The Augmented Reality application is connected to the real-world circuit by camera and via Bluetooth, which additionally enables the measurement and presentation of real-life data via the app. A study was conducted with 200 secondary school students, investigating the effects of the use of the applications on their conceptual knowledge and the cognitive load they experienced while learning. To explore potential moderating effects, the student's affinity for technology and their spatial visualization skills were measured prior to the intervention. This contribution presents the application "PUMA : Spannungslabor", the design, material and method of the student lab study and shares the

results of the study, which is currently ongoing.

494 Designing a Course to Promote Digitally Transformed Thinking Among Future Maths and Science Teachers

Angelika Bernsteiner[1], Thomas Schubatzky[2], Philipp Spitzer[1], Claudia Haagen-Schützenhöfer[1]

[1]University of Graz, Graz, Austria. [2]University of Innsbruck, Innsbruck, Austria

Abstract

Comprehensive digital competencies and an understanding of digital transformation are needed to participate in our digitally changing society. To meet this need at school, teachers are required who are well prepared to promote these competencies and this understanding to students. It is therefore important to provide future teachers with appropriate learning opportunities within their teacher training. In order to professionalize future mathematics and science teachers to implement digitally transformed subject teaching, the course *"Facts, Fakes and Algorithms"* is developed and researched. The overarching goal is to provide future teachers with an understanding of digitality and digital transformation. The course is developed and researched according to the paradigm of Design-based Research. The design of individual learning opportunities is based on theoretical foundations and empirical findings. Stalder's concept of digitality and Puentedura's SAMR model are used as a theoretical framework to promote understanding of digitality and digital transformation. In addition to practical application of digital media, the course stimulates reflection processes on the use of digital media for digital transformation of teaching. The course design was first implemented in summer semester 2022 with 17 students. The learning effectiveness of the course design and students' learning processes were investigated using a mixed-methods approach. Based on the research results, the course design was further developed. In winter semester 2022/23, the adapted course design was implemented with 13 students. Preliminary results show that teaching theoretical content on digitality and digital transformation is not sufficient to enable future teachers to reflect on digital transformed teaching. We were able to derive the design assumption that future teachers need to be exposed to examples of educational practice in order to understand digital transformation. Furthermore, our findings suggest that future teachers need solid technical and digital competencies to be able to think about teaching in a digitally transformed way.

Parallel Session - 8.2 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Geraldo Witeze Junior

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802 Lessons Learned From Implementing Digital-TSPCK

Mpumelelo Faith Zondi, Elizabeth Mavhunga

University of Witwatersrand, Johannesburg, Gauteng, South Africa

Abstract

The purpose of this study was to explore the lessons learned from implementing a newly refined construct for teacher knowledge for teaching in the digital realm called Digital-TSPCK. The study employed a qualitative research design with a sample of 8 Post Graduate Certificate in Education (PGCE) Pre-service teachers(PSTs) who were exposed to an explicit intervention in their methodology course. Data collected were post-intervention PST's purposefully built digital-TSPCK based teaching videos on Chemical Equilibrium. Furthermore, teacher reflections about the factors that facilitated and hindered the development of digital-TSPCK were collected through recorded stimulated recall interviews with all PSTs. Analysis of this data entailed familiarization: playing of the submitted videos over and over searching for segments with digital-TSPCK episodes, listening to audio files and reading transcripts in their entirety a number of times for major themes to emerge. Identifying a thematic framework: lifting quotes from the original context and rearranging them and, mapping and interpretation. The findings revealed that the quality of the identified digital-TSPCK episodes varied in extent of pedagogical transformation of content knowledge, and elements such as the teachers' digital competency, face to face vs. online tutorials, and peer-to-peer assistance were facilitating factors, while the lack-of in some cases became hindering factors. Of high interest, was the observation in the identified digital-episodes of the complimentary interactions between the traditional components of TSPCK and the principles of multimedia learning. Implications drawn include recommendation for the implementation of digital-TSPCK with emphasis on pedagogical knowledge transformation, digital functionality and a learning theory for multimedia settings.

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867 Digital Media at Out-of-School Places of Learning From the Point of View of Future Science Teachers in Primary Schools

Annkathrin Wenzel, Jan Roland Schulze, Eva Blumberg

Paderborn University, Paderborn, Germany

Abstract

Digitisation and digital media, as well as out-of-school places of learning, have long been of great importance for the German school system. Both concepts are required for the teaching

of science in primary schools. The combination of the two concepts has barely been researched up to this point. This is to be changed in the present interview study. The aim is to find out the opinion of future teachers on the use of digital media in out-of-school learning. As a consequence of the interviews and the results, relevant contents and events could be increasingly integrated into the teaching of future teachers. The seminars are created in a way that using digital media in different ways and at out-of-school learning places become attractive enough that they demonstrate broad academic potential to a heterogenous group of students in primary school.

1108 Utilizing Computational Thinking to Enhance Learning in Electricity – a Case Study

Thomas Frågåt[1], Katarina Pajchel[2], Louise Mifsud[2]

[1]Inland Norway University of Applied Sciences, Hamar, Norway. [2]Oslo Metropolitan University, Oslo, Norway

Abstract

Computational Thinking (CT) has been introduced to curricula in several countries in a variety of ways, both integrated within specific subjects and as a subject in its own right. Despite the prominence given to CT in curricula, definitions of CT vary. Furthermore, integrating CT into subject-specific learning is experienced as challenging. Through a case study, we explore how CT can be integrated into science teaching to enhance subject-specific learning. Data were collected using video recordings and analysed thematically. Our findings indicate that in learning science through CT, the students worked in systematic ways where science was foregrounded, but where CT was a crucial element in solving scientific problems.

1024 Science and Religion in Dialogue – Emerging Findings From a Brazilian School Study

Geraldo Witeze Junior[1], Camila de Vasconcelos Tabares[2], Daniel Ordine Vieira Lopes[3], Michael Reiss[4], Rangel Godinho[1]

[1]Federal Institute of Education, Science and Technology of Goiás, Anápolis, Goiás, Brazil. [2]Federal Institute of Education, Science and Technology of Goiás, Luziânia, Goiás, Brazil. [3]Federal Institute of Education, Science and Technology of Goiás, Formosa, Goiás, Brazil. [4]University College London, London, United Kingdom

Abstract

Existing research reveals a lack of consensus about students' attitudes towards the relationship between science and religion. Most of the existing research has been conducted in the global North, yet the significance of religion for people's lives varies greatly around the globe. This study seeks to answer the research question 'How do Brazilian school students view the relationship between science and religion?'. Our initial findings come from a questionnaire completed by 109 Brazilian school students aged 15-19. Unsurprisingly, those with more

interest in religion were more likely to hold creationist views. However, there was a spectrum of opinions with none of the students being categorised as entirely creationist and only 26.9% as non-creationist. Those who identified as being right-wing were more likely than those who identified as left-wing to believe that human activities do not influence the rise of sea levels and the melting of polar ice caps. They also had poorer knowledge about climate change and were more likely to favour religion over science when the two were seen to conflict.

Parallel Session - 8.3 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Salome Flegr

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593 The Impact of a Graduate Course on the Development of Technological Pedagogical Content Knowledge

Gamze Çetinkaya Aydın, Jale Çakıroğlu

Middle East Technical University, Ankara, Turkey

Abstract

The purpose of this research is to examine the impact of a graduate course on graduate level science education students' development of technological pedagogical content knowledge (TPACK). Following a design-based research approach, a graduate level TPACK course design was created to promote science teachers' TPACK based on the relevant literature. The proposed design was implemented in two iterative cycles. Participants of the study were 12 graduate level students pursuing an M.S. or Ph.D. degree in elementary science education. The course design created to be implemented in the graduate course was composed of three stages named as Theory, Application, and Practice. Data were collected by means of lesson plans and interviews. Data analysis revealed that after attending the graduate course based on Theory-Application-Practice (T-A-P) course design, all of the participants' levels of TPACK progressed at different levels in both cycles of implementation. T-A-P course design was created to offer a solution to the problem of identifying effective strategies for the TPACK development of teachers. Findings revealed that T-A-P course design, prepared by combining various principles found to be effective for TPACK development in different studies, was effective for graduate science education students' TPACK development.

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902 The Impact of Augmented Reality During Chemical Hands-on Experiments on Learning and Cognitive Load

Hendrik Peeters[1], Sebastian Habig[2], Sabine Fechner[1]

[1]Paderborn University, Paderborn, Germany. [2]Friedrich-Alexander-Universität Erlangen-Nürnberg, Nürnberg, Germany

Abstract

Chemical phenomena can only be observed on a macroscopic level, but are explained by submicroscopic entities. Students often struggle to connect these different levels of representation. Augmented Reality (AR) technology offers a way to bridge this gap. By integrating virtual models into hands-on experiments, it might be possible to increase spatial and temporal contiguity. The study to be presented evaluated the impact of AR on student learning and cognitive load during hands-on experiments. A total of 104 German secondary school students were divided into three groups: AR, animation, and filmstrip. The AR group used an AR app during two hands-on experiments while the animation and filmstrip groups were provided with dynamic or static models after the experiments. The results showed that the AR group did not have a significant increase in learning compared to the other groups and had higher intrinsic cognitive load in both experiments and higher extraneous load in the second experiment. These findings suggest that AR did not fully achieve its potential in this study.

1061 Web 2.0 Activities Based STEM Education: Pre-Service Teachers' Views

Nezih Önal, Işıl Akçay

Niğde Ömer Halisdemir University, Niğde, Turkey

Abstract

Teachers are expected to adopt the understanding of STEM education and reflect it in their practice in the learning environment. For this reason, it is considered that examining teachers' opinions on STEM-based web 2.0 applications in detail is important. The aim of the current research is to examine the views of pre-service teachers on web 2.0-based STEM education. Thirty-five pre-service teachers participated in the research patterned with the case study. Content analysis was used to analyze (evaluate) the data. The findings showed that participants generally expressed a positive opinion towards web 2.0-based STEM education. Participants believe that these tools are suitable for the new generation of learners and their use in STEM education will contribute to students' cognitive and affective learning. In addition, various benefits for teachers such as enabling them to improve themselves and being aware of new technologies are mentioned. On the other hand, some participants think that this training can lead to some problems such as cost, health problems and not supporting social skills. It is possible to make various recommendations in line with the results. One of the most general recommendations may be to put web 2.0-supported STEM education at the center of education at all levels.

1136 Inquiry Learning in Science Education With Combined Real and Virtual Experiments

Salome Flegr[1], Jochen Kuhn[1], Katharina Scheiter[2]

[1]Ludwig-Maximilians-University Munich, Munich, Germany. [2]University of Potsdam, Potsdam, Germany

Abstract

One fundamental aim of science education is fostering students' conceptual understanding. The instructional approach of inquiry learning has proven to be one possibility to effectively foster this understanding of concepts. Inquiry learning has traditionally always been implemented with real, hands-on experiments. Nowadays, digital technologies also allow for the implementation of virtual experiments (interactive simulations). Recent research suggests that combinations of real and virtual experiments are more effective for improving students' conceptual understanding than single experimentation formats alone. However, more research is needed in this behalf concerning different learning topics and age groups than in the previous studies. Moreover, the role of sequencing these experimentation formats is yet unclear. In the present study, 186 middle school students were involved in inquiry learning in a physics lesson. They worked either with a combination of real and virtual experiments in two different sequences or with the real, hands-on experiment only. In line with our hypotheses, inquiry learning fostered students' conceptual understanding in physics and students in the combination conditions learned more than students in the single experiment condition. The superiority of learning with combined real and virtual experiments can be explained by the complementary advantages offered by the different experimentation formats. Moreover, we investigated whether one sequence of experiments might be better than the other, but both combinations were equally effective for fostering students' conceptual understanding. In conclusion, this study suggests that combinations of real and virtual experiments can be recommended for inquiry learning in science education regardless of their sequence.

Parallel Session - 8.4 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Katarina Pajchel

1084 Primary Students' Misconceptions About Fossils: Using a Digital Story

Birgül Çakır-Yıldırım

Agri Ibrahim Cecen University, Agri, Turkey

Abstract

The aim of this study was to develop a digital story to improve the understanding of 4th grade primary school students about fossils and remove their misconceptions, to investigate how effective the developed digital story to eliminate the misconceptions of 4th grade students about fossils and to investigate students' thoughts about the digital story about fossils. We found that the digital story helped elimination of many misconceptions about fossils (e.g., fossils are found only in rocks, fossils are only bones, the only living fossils are dinosaurs.). However, students had difficulties about the time the fossils lived and the age of fossils, even after the application. Based on this result, we suggest that an education should be given to the students

about the formation of the earth and geological times before the teaching of fossils and the curriculum should be expanded in this way.

1102 Digital Literacy in Turkish High School Science Textbooks

Aliye Tuba Gülsoy, Mustafa Çakır

Marmara University, İstanbul, Turkey

Abstract

In the 21st century, many innovations have been reflected in the educational sector and changed teaching and learning practices. Changes in the process of acquiring and using knowledge, differentiating student characteristics, innovations in accessing digital resources, and changing understandings of what to learn and how to learn required rethinking traditional methods and reforming education. One of the skills that entered the curriculum and textbooks with the education reforms is digital literacy. In this context, it is necessary to examine science textbooks in terms of digital literacy. The aim of this study is to examine the high school science textbooks approved and distributed by the Turkish Ministry of National Education in terms of digital literacy. Within the scope of the study, a textbook evaluation rubric was developed based on the UNESCO Digital Literacy Competence Framework. The study was carried out with a qualitative research approach and document analysis was used as a research design. Research data were analyzed by the comparative descriptive analysis method. The references to digital competence areas in textbooks increase with the increase in grade level. In the books examined, the area of competence that takes place at the highest rate at all grade levels is "information and data literacy". There is no content in the textbooks within the scope of "career-related competencies". The level of including "security" and “problem-solving" competencies in the reviewed books is quite low. It can be expected that references to "problem-solving" competencies would be higher in high school science textbooks since high school students are expected to have required higher-order thinking skills and required cognitive abilities. Additionally, it is very important to provide the new generation of students, who are digital natives, with security-related competencies such as understanding the risks and threats in the digital environment and protecting personal data and privacy.

1110 Computational Science Databases Opportunity and Challenger for STEM Education

Jorge Rodriguez-Becerra, Freddy Carrasco, Lizethly Cáceres-Jensen

Universidad Metropolitana de Ciencias de la Educación, Santiago, Chile

Abstract

The need to identify scientific databases that can be used to design learning environments to solve authentic problems in computational chemistry, computational biology, chemoinformatics and bioinformatics becomes of great importance to developing computational thinking skills in the student. This study displays a systematic literature search

conducted in the Web of Science (WoS) database and a bibliometric analysis related to the databases in science. Finally, since the projections of generation and uses of scientific databases are increasing, it is necessary to train science teachers to identify, discriminate and use the available databases for new designs for STEM education activities.

1140 Development of Pre-Service Teachers TPACK in the Context Programming in Science Education

Katarina Pajchel, Håkon Swensen, Birger Brevik, Per Øyvind Sollid

OsloMet - Oslo Metropolitan University, Oslo, Norway

Abstract

In 2020 Norway implemented a new curriculum which introduced computational thinking (CT) and programming leading to a need for knowledge about how to integrate this in science teacher education. The aim of this study is to explore the design of a pre-service teacher (PST) course which combines introduction of fundamental concepts in programming and teaching practices relevant to science education in primary and lower secondary schools. The research question is: What competencies regarding teaching and using programming in science education do PSTs report having gained from participating in a module that integrates technology, programming, and pedagogy? Data consisting of 6 semi structured group interviews was analysed using the technological pedagogical content knowledge (TPACK) framework (Mishra & Koehler, 2006). When students started the introductory programming tasks, they found that it was not as intimidating as they had previously thought. The study shows that introduction to programming was helped by the low-threshold, open and informal activity, resulting in student experiencing mastery. Students reflected on a wider range of applications of programming in science education as an exploratory approach to problem solving. Students expressed that their sense of self-efficacy regarding teaching and doing programming in science education developed during the course. Results indicate that the course design which combines first-hand programming experience with progressively more pedagogical tasks in which the students develop their own science and technology teaching using programming, contributes to the development of students' TPACK.

Parallel Session - 8.5 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Ricarda Ringdorfer

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600 How Science Teachers Use Visual Representations in Their Teaching: A Study on the Pedagogical Dimension as Part of the Representational Surveillance

Ignacio Idoyaga[1], María-Gabriela Lorenzo[1,2]

[1]Universidad de Buenos Aires, Buenos Aires, Argentina. [2]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Buenos Aires, Argentina

Abstract

This article presents a descriptive study on the different types of visual representations and their pedagogical use that science teachers include in their teaching, contributing to the process of Representational Surveillance. In this line, visual representations have been classified according with their relation between the representation and the represented object as follows: Graphics; Diagrams; Maps; Pictures. Furthermore, VR can be applied in teaching practices in different ways such as: expositive use in lectures, problem solving use or instrumental use throughout experimental activities. Meanwhile, in scientific language VR play different roles that could be considered a theoretical use to model some phenomena, and an experimental use to manage to empirical data. The methodology included the design of an online questionnaire that was applied to 39 university teachers of health sciences. Descriptive statistics was used to analyse the responses to the multiple-choice questions and content analysis was used for the responses to the open questions. In addition, visual representations provided by the participants were reviewed. The results showed that majority of the participants used Pictures of theoretical models for expository purposes. These results could imply an understanding of Visual representations as elements of theoretical rhetoric by students. The conclusions highlight the contribution of this research to the representational surveillance process as a systematic strategy for collecting evidence for the design of teaching with visual representations. In addition, beyond the need to continue the study of the dimensions of representational surveillance, the results of this work already contribute to rethink and then, to redesign Science teaching practices at university.

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423 Dialogic Collaboration for Planning an Early Childhood STEAM Workshop

Sergei Glotov, Doriana Sportelli, Christina Siry

University of Luxembourg, Esch-sur-Alzette, Luxembourg

Abstract

This research focuses on the collaborative process between four science teachers and a group of educational researchers for developing an Early Childhood STEAM workshop. It explores the advantages and challenges of having an ongoing dialogue from different perspectives during the planning process. Using video recordings of planning sessions and observation notes as research data, this study adopts both analytical and interpretive approaches to content analysis. We conclude that that the dialogic, open-ended structure of the planning sessions: i) creates a space for positive emotions to emerge, ii) distributes leadership among the participants, iii) is open-ended and backward designed.

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666 Empirical Investigation junior School Students' Modeling Competence Improvement in STEM-Project-based Learning

Xiao HUANG[1], Jiaying Xie[1], Jiannan QIU[1], Yingce WU[2]

[1]Zhejiang Normal University, Jinhua, Zhejiang, China. [2]China Association of Higher Education, Beijing, Beijing, China

Abstract

The project of "STEM in the side door lock - the construction, production and application of intelligent door control system model" comes from the real life situation, integrates the STEM education concept, relies on scientific inquiry activities, and takes the engineering design process as the main line.Participants experienced modeling practice activities such as model construction, learned and applied modeling knowledge and modeling methods.The research found that junior high school students' modeling competence has been improved to different degrees in the dimensions of model use and model comparison, but there are also a few dimensions in which the improvement is not ideal.Combining the quantitative results and qualitative analysis, this paper puts forward the STEM-Project-Based learning design suggestions for improving students' modeling competence.

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720 Teaching Continuous Flow Chemistry in a Master's Laboratory Course

Ricarda Ringdorfer, Doris Dallinger, C. Oliver Kappe, Philipp Spitzer

University of Graz, Graz, Austria

Abstract

Continuous processing nowadays is a key technology in the pharmaceutical manufacturing sector as well as in academic research. Compared to conventional batch processes, syntheses in continuous flow have numerous advantages. However, flow chemistry is hardly implemented in academic laboratory courses. Here we present the development and implementation of a flow chemistry laboratory course for a Master's programme in the field of technical chemistry with the focus on the didactical design of the lab course. In this context the structure relies on inquiry-based learning, to enable students to work and learn independently. Considering the

students' prior knowledge and learning opportunities about flow chemistry, a digital learning environment was designed to support the heterogenous students' group. Due to the fact that continuous flow systems are rather expensive, a 3D printed flow reactor was employed. Based on action research, we use a mixed-methods design consisting of qualitative content analysis of curricula, students interviews and pre- and post-surveys.

Parallel Session - 8.6 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Giancarlo Artiano

1072 Affective Domain and Soft Skills in Science Laboratories: A Systematic Review

Merve YAVUZ[1], Jale ÇAKIROĞLU[2]

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Abstract

The purpose of the present study is to review the impact of science laboratories on students' soft skills and affective dimensions in science laboratory sessions. To have a broad view about the issue, a systematic review was conducted by examining articles published in the three most-cited scientific journals in the field of science education in the last five years. The findings suggest that science laboratories not only enhance students' cognitive understanding of science concepts, but also contribute to the development of their soft skills such as teamwork, problem-solving, and communication. Additionally, the review highlights the significance of affective dimensions in science education, including students' attitudes toward science, motivation to learn science, engagement with scientific concepts and practices, sense of agency in laboratory sessions, careermaking, aesthetic appreciation, and psychological growth.

1127 Different Strategies of Answering Questions Related to Textbook Material Viewed by Eye-Tracking

Alžběta Krejčí, Martina Kekule

Charles University, Prague, Czech Republic

Abstract

Recording eye movements could provide valuable online data about pupils' learning or problem solving, as observed on textbook excerpts with accompanying questions. Two groups were compared, group 1 reading text from textbook with questions which were answered directly in the text, and group 2 reading text from textbook with questions loosely related to

the text but not answered in it. Qualitative review of strategies showed no significant differences, however quantitative data (total fixations duration and fixations count) suggested meaningful difference in cognitive load between the two groups. Specifically that material with questions answered directly in the text was cognitively less demanding than the material with loosely related questions.

1283 Students' Notions About Bioethical Issues- a Comparative Study in Indian Subcontinent

Astha Saxena

Azim Premji University, Bengaluru, Bengaluru, India

Abstract

The present study is based in Indian subcontinent and aims at exploring students' conceptions about ethical issues related to Biotechnology at both high school and undergraduate level. The data collection methods involved taking classroom notes, recording students' observations and arguments, and focussed group discussions with students. The data was analysed using classroom discourse analysis and interpretive approaches. The findings depicted different aspects of students' thinking, meaning making and ethical understanding with respect to complex bioethical issues such as genetically modified crops, in-vitro fertilization (IVF), human genomic project, cloning, etc. at high school as well as undergraduate level. The paper offers a comparative account of students' arguments with respect to ethical issues in biotechnology at high school & undergraduate levels where it shows a clear gradation in their ethical understanding from high school to undergraduate level which can be attributed to their enhanced subject-matter knowledge. The nature of students' arguments reveals that there is more reliance on the utilitarian aspect of these biotechnologies as against a holistic understanding of a particular bioethical issue. This study has implications for science teachers to delve into students' thinking and notions about ethical issues in biotechnology and accordingly design appropriate pedagogical approaches.

1293 From University to Kindergarden: Research Activities in Teaching and Learning Physics in Formal and Informal Contexts.

Giancarlo Artiano[1,2], Emilio Balzano[3]

[1]Vanvitelli University, Caserta, Italy. [2]Suor Orsola Benincasa University, Napoli, Italy. [3]Università degli studi di Napoli Federico II, Napoli, Italy

Abstract

What role does physics play in large-scale science education? This is one of the many questions that we have been pondering over. We believe that research in physics education can make a substantial contribution, especially nowadays, to tackle the problem of the estrangement of the general public from science issues. It is necessary to act on several sides not only by permanently supporting schools and universities to reflect on ways of teaching and learning

physics, but also by valuing cultural experiences in informal contexts. The activities of our research group, documented on a website, are characterized by sharing a non-traditional way of doing science with people. In our experience, the meaning of physical and mathematical theories is understood when the people's interpretations of reality resonate with the formal models that physics has of reality. A cognitive resonance model-based approach can help people to understand the meaning of models in physics and to develop critical thinking. It seems to us that, after years of great deal of efforts, the results achieved have been judged very promising by all subjects involved, and adequately respond to the needs of the territories in which we operate.

Parallel Session - 8.7 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Berfin Huraibat

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719 First Outcomes of a Teaching-Learning Sequence on Quantum Information and Computation Based on the Model of Educational Reconstruction

Massimiliano Malgieri, Claudio Sutrini, Giacomo Zuccarini, Chiara Macchiavello

Department of Physics, University of Pavia, Pavia, Italy

Abstract

In this work we report on the results of the first refinement cycle of a teaching learning sequence based on the educational reconstruction of quantum information and computation at the level of secondary school. The results will serve as the base for refinements and improvements of the sequence, in view of a new testing cycle bound to start in late spring 2023. The results hereby discussed concern two teaching experiments, held between spring and summer 2022, one in curricular teaching, guided by the classroom teacher, and one in the context of a vocational summer school.

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807 The Tale of the Chemistry Laboratory Classes: Probing High School Students' Experiences in Blended Learning Environment

Hazel Joyce Ramirez

University of the Philippines College of Education, Quezon City, Philippines

Abstract

Chemistry laboratory activities cultivate scientific inquiry that enable students to experience and discover scientific processes and occurrences. The transition from online to face-to-face chemistry laboratory implementation merits investigation since valuable insights to create relevant and learner-centred classroom environments could be gained. Research examining

the synergy of online and face-to-face modalities in the context of post-pandemic education is still in its formative years. Drawing from this premise, this study aimed to analyse the insights and experiences of senior high school students in a chemistry blended learning environment. The tale of the chemistry laboratory classes signifies the crossing of salient features of virtual and face-to-face instructional activities to optimize science learning. This research utilized a case study approach that involved fifteen (15) Grade 12 STEM students. Data sources include responses to survey questionnaire and semi-structured interviews which elicited students' insights and experiences on blended learning. Thematic analysis revealed several themes such as social interaction, lesson understanding, affective domain, and course design and resources that encapsulate the benefits, challenges, and suggestions for improvement of blended learning environment. These findings shed light on the redesigning of both the online and face-to-face components of blended learning into a seamless science learning environment amid the transition in the educational landscape.

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883 Supporting Productivity of Failure by Making Underlying Mechanisms Explicit

Julia Hiniborch, Gunnar Friege

Leibniz Universität Hannover, Hannover, Germany

Abstract

Productive Failure seems to support conceptual knowledge acquisition when teaching math. Nonetheless, studies, in which not all underlying mechanisms were triggered, did not show learning benefits. We want to examine whether making the underlying mechanisms explicit supports learning when teaching physics. By implementing three different teaching scenarios (Productive Failure, Productive Failure with mechanisms made explicit and control condition), we are able to compare student learning. Even though knowledge tests from students in tenth grade did not show differences between these scenarios, interviews with teachers suggested that additional aspects should be considered to benefit from this approach. It remains to be seen whether these results will be supported by the results from students in grade eleven which are currently being conducted or if additional prior knowledge makes a difference.

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886 Examining Preservice Chemistry Teachers' Understanding on Equilibrium From Kinetic and Thermodynamic Perspective

Berfin Huraibat[1,2], Emine Adadan[1], Filiz Kabapınar[2]

[1]Bogazici University, Istanbul, Turkey. [2]Marmara University, Istanbul, Turkey

Abstract

This mixed-methods study examined the change in preservice chemistry teachers' understanding of physical and chemical equilibrium from pre to postinterview as they involved in the multirepresentational instruction that specifically addressed the concept of equilibrium

at three representational level (macro, submicro and symbolic) as well as promoting the cause-effect relationships in the students' explanations from kinetic and thermodynamic perspectives. Qualitative data were collected through semi-structured individual interviews from a total of 13 preservice chemistry teachers. The data source consisted of tasks that required explaining why and how physical and chemical changes begin and reach equilibrium, and how the process progresses after equilibrium from both kinetic and thermodynamic perspectives. Verbal data were coded and analyzed using quantitative methods. A statistically significant difference was observed for preservice chemistry teachers' understandings of equilibrium concepts.

Parallel Session - 8.8 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Haira Gandolfi

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870 Students' Perception of Physicists' Work

Moritz Kriegel, Verena Spatz

Technical University of Darmstadt, Darmstadt, Hesse, Germany

Abstract

Many students hold stereotypical perceptions of the work of scientists. These may result in a lower interest in science and can lead to ill-considered career choices. This paper aims to compare students' stereotypes with the self-reported perception of the everyday work of researchers in physics. To this end we determined activity profiles among physicists in a Collaborative Research Centre for nuclear- and astrophysics using an adapted RIASEC+N model based on the theory of vocational choices by Holland. We are now conducting a questionnaire study with high school students to identify their beliefs about the work of physicists. Preliminary results show that the majority of students have mostly undifferentiated notions about the professional activities of physicists. The activities in the field of theoretical physics seem to play a particularly subordinate role. In the future, these results will be used to develop an outreach programme to give students an authentic insight into modern physics research.

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457 (Re)thinking Science Education in the Face of Socio-Scientific Challenges and Injustices: Insights From Critical & Decolonial Practices to a Socio-Political Turn for Nature of Science

Haira Gandolfi

University of Cambridge, Cambridge, United Kingdom

Abstract

Throughout the past decades, global challenges of socio-scientific nature such as the COVID-19 pandemic, climate degradation, and racism brought many relevant and pressing questions to the fore of the science education field. Fake news, climate change denialists, environmental injustices, unequal distribution of access to health care (e.g. vaccines, and disproportionate pandemic impacts over different populational groups), and the return of fringe scientific racism discourses (Saini, 2019) have been pushing science educators into (re)thinking the purposes and roles of science education within a landscape where the links between science, and socio-political challenges, injustices, citizenship and democracy have become increasingly complex. Within this scenario, in this presentation I will specifically examine what critical, socio-political and social justice-informed frameworks and practices – especially Critical Pedagogies and Decolonial Thought – can bring to the area of Nature of Science (NOS) teaching and learning. Grounded on examples from school science practices, curricula and science teachers' own voices in England, and on wider reflections as a former science student and teacher in Brazil, I hope to illustrate how such critical and decolonial approach to NOS can contribute to (re)thinking science education for this age of growing socio-scientific challenges and injustices through the explicit engagement by NOS with important critical-decolonial notions, such as critical consciousness, education as a socio-political endeavour, ecologies of knowledges and abyssal lines.

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304 Evaluation and Validation of the Students' Understanding of Models in Science Instrument

Ayşegül Yazan, Mustafa B. Aktan

Hacettepe University, Ankara, Turkey

Abstract

Understanding the nature of scientific models in science teaching and learning the concepts of model and modeling are important both for the development of scientific process skills, and for learning the nature of science. Many studies in the scientific literature for students and teachers advocate the development and dissemination of model-based teaching practices. In order to support model-based science education, students' perceptions of scientific models should be investigated, and the nature of scientific models and modeling should be supported. One of the measurement tools commonly used in such studies is the Students' Understanding of Models in Science (SUMS) scale. The scale was translated into many languages and applied to various individuals in different sociocultural settings. Some studies that have translated and used the scale in recent years are problematic in terms of reliability and validity, state that the scale was used without providing language and construct validity. In addition, various criticisms were made about the items and factor structure of the scale. The aim of this study, taking into account the criticisms and problems raised, is to determine what kind of results the SUMS scale revealed on Turkish speaking students by examining the language and construct validity of the scale. After the cultural and linguistic compatibility of the scale was ensured, the construct

validity and model fit were examined with confirmatory factor analysis on the data collected from secondary school students. The results show that the adapted Turkish SUMS scale has internal consistency, and the factor structure and its model fit the data. Some problems regarding the items and factor structure previously reported in the literature were also observed in our study. The results of more detailed analyses show that the scale needs improvement, but the Turkish SUMS scale can contribute to the examination of students' perceptions of scientific models.

165 Assessing the Impact of Understanding Nature of Scientific Knowledge and Nature of Scientific Inquiry on Learning about Evolution in High School Students

Juan Jimenez[1], Norman Lederman[2], Judith Lederman[2]

[1]University of Talca, Linares, Maule, Chile. [2]Illinois Institute of Technology, Chicago, Illinois, USA

Abstract

Nature of Scientific Knowledge (NOSK) and Nature of Scientific Inquiry (NOSI) are important components of scientific literacy and important educational objectives in science education. Some authors theorize that NOSK and NOSI increase students' understanding of science content knowledge, but this assumption has not been empirically tested yet. The main purpose of this study was to empirically test the assumption that understanding NOSK and NOSI improve learning about evolution. Using a quasi-experimental design, a sample of 453 9th grade students from 12 classes were randomly assigned to intervention and control groups. Students in the intervention groups received a special five-week NOSK/NOSI Unit and a five-week Evolution Content Unit (ECU), as treatment. Control groups only received the ECU. VNOS D+, VASI, and an Evolution Content Test (ECT) were used to measure understanding. The results showed that the NOSK/NOSI Unit was effective in improving understanding of NOSK and NOSI in the intervention groups, and the ECU was effective in improving understanding about evolution in both groups, but intervention groups outperformed their peers in the control groups by scoring higher on the ECT. All aspects except "theories and laws" (NOSK) had a significant positive impact on learning about evolution. The findings suggest that understanding NOSK and NOSI appears to improve learning about evolution and provide new insights about the relationship between understanding NOSK, understanding NOSI and learning about evolution.

Parallel Session - 8.9 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Frederic Charles

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303 An Argumentation Study Portraying Students' Engagement in Argumentation Process

Mehmet Şen[1], Semra Sungur[2], Ceren Öztekin[2]

[1]TED University, Ankara, Turkey. [2]METU, Ankara, Turkey

Abstract

This study investigated two 6th grade classes' (N=35) engagement in the argumentation process in the context of matter and heat unit and electricity unit. Data were collected from whole class discussions. During data collection, class discussions were video-recorded. Data collection lasted six weeks. Transcribed data were deductively analyzed in this case study using the codes obtained from Sampson and Clark's (2011) study. The codes are expositional comments (e.g., proposing ideas), oppositional comments (e.g., refuting ideas), information seeking (e.g., asking for further information), and co-construction of knowledge (e.g., adding ideas). The analysis process included two steps. In the first step, frequency analysis was done for each week considering four engagement codes. In the second step, assertions were proposed using the data coming from frequency analysis. The findings of the study revealed four assertions regarding students' engagement in the argumentation process. First, the use of expositional comments dominated the class discussions. Second, students tended to use oppositional comments when they had prior knowledge and evidence cards are provided to them. Third, students mainly used information seeking when they conduct the experiments. Last, co-construction of knowledge was the least used engagement component in the study. Discussion and implications about assertions regarding students' engagement in the argumentation process are also presented.

1073 Circular Social Metabolism in the Classroom: A Proposal for Social Action and Argumentation About Sustainable Eating

Marina Nieto-Ramos, Fátima Rodríguez-Marín, Lidia López-Lozano, María Puig-Gutiérrez

University of Seville, Seville, Spain

Abstract

Based on a linear social metabolism, the current consumption model, which exceeds planetary limits, is putting at risk the availability of water and nutrients in the soil that sustain food systems. In this scenario, learning how to use resources rationally and how to defend our proposals in a critical manner is the most appropriate path toward global sustainability. The present study

explores how the knowledge of future Early Childhood Education teachers evolves regarding the use of organic waste as soil nutrients and how to reduce water consumption in food growth, which solutions they propose to these problems and how their level of argumentation evolves, after participating in a sequence of activities on sustainable food. The data were collected from the thoughts given by the students in the 3rd year of the Early Childhood Education degree. They were analyzed using two systems of categories, one created ad hoc to analyze the solutions and another adapted to analyze the level of argumentation. The results show that: a) the students have a medium level of knowledge of circular social metabolism in relation to the problems studied; b) most of the ecological proposals for reusing wastes are related to production, and when talking about saving water the ecological proposals are focused on the consumption of resources/produced goods; and c) working on socio-environmental problems in a research manner in the classroom seems to favor the development of critical and argumentative skills.

1120 Role of Declarative Knowledge in Pre-Service Physics Teachers' Explanations During Dc-Circuit Tasks

Terhi Mäntylä, Anna-Leena Kähkönen, Kati Järvinen, Pasi Nieminen

University of Jyväskylä, Jyväskylä, Finland

Abstract

The ability to explain or support students to construct explanations is one key competence of a teacher. There are different aspects relating to the quality of explanations and in this case study, we examined, how declarative knowledge affects to the quality of pre-service teachers' explanations. This was done in the physics context of predict-observe-explain-tasks of brightnesses of bulbs in DC-circuits. The data consists of transcribed discussions of two pre-service physics teacher pairs during solving the tasks. The pre declarative knowledge was evaluated using DIRECT test. The pair 2 had higher score than pair 1. The data was analysed using content analysis and the quality of explanations and the role of declarative knowledge in it was examined from different perspectives, e.g. used concepts and their relations, heuristics and misconceptions. The results show that better declarative knowledge leads to higher quality explanations, and it also enables to recognize what needs to be explained. However, both pairs used quite narrow declarative knowledge, which could lead to limitations in providing instructional explanations in their future profession.

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197 One Small Step of Learnings about the Moon for Pre-Primary Pupils

Frederic Charles

Laboratoire de Didactique André Revuz, CY PARIS UNIVERSITE, France

Abstract

This presentation aims to explore the potentialities of a fictional storybook named "To have class on the Moon" (Hare, 2019). This children's literature book takes place on the Moon and

shows realistic spacesuit, lunar surface, and views from the Earth. The content analysis of the narrative shows the potentiality to approach biological and physical contents linked to the Moon's characteristics and the necessary conditions of life's development. This research was undertaken in two classes of a French pre-primary school, with pupils aged from 4 to 5 (N=50). A teaching and learning sequence was built and implemented by two teachers, which have been involved in a collaborative research group. We will present the data regarding the three first sessions, which aims to assess how the storybook's illustrations may encourage the pupils into a questioning about the Moon's characteristics and the necessary conditions for the development of life. The analysis of drawings and two collective debates proves that this storybook offer an activity full of sense and motivation for pupils. Moreover, this data allows us to say that the interpretation of the story can be a way to engage young pupils in their first steps to problematization about the necessary conditions for life and knowledges about the Moon.

Parallel Session - 8.10 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Clas Olander

1189 Students´ Meaning Making of Words in Science

Clas Olander[1], Sofie Johansson[2]

[1]Malmö University, Malmö, Sweden. [2]Gothenburg University, Gothenburg, Sweden

Abstract

The language in science classrooms has specific characteristics related to the use of words, grammar, and semantic patterns that may be a particularly challenging issue for students meaning making of science phenomena. The aim of the presented project is to investigate language related issues in relation to meaning making of school science in multilingual settings. This is done through a multidisciplinary (science education and linguistics) and quantitative approach in Swedish secondary schools. The research question is "what kind of words are challenging for students with Swedish language background and students with other language backgrounds". Meaning making of words was estimated through web-based vocabulary tests given to 232 students in grade 7-9. In addition, the students were asked about their first language and how long time they studied in Swedish school. This data made it possible to calculate potential significant differences between groups of students and categories of words. On a general level, significant differences were found between the performance of students with Swedish as mother tongue and those with other mother tongues and within the group that arrived in Sweden later than school start. When focusing word types, we found differences between the groups in relation to two categories: "general academic words" (e.g. cause and consist of) and "colloquial but content related words" (e.g. pass and branch). On the other hand, difficult word categories for all students were "academic and content-related words" (e.g. trait

and process) and "academic and content-typical words" (e.g. occur and indicator). We argue that, especially regarding students with another mother tongue than the language of instruction, it is important to give attention to the words that are general academic words along with the common focus on content-specific words – the concepts.

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826 Student Perception of Their Development of Creativity in a STEAM Project for Primary Education

Ros Germán, Iñigo Rodríguez-Arteche

Universidad de Alcalá, Alcalá de Henares, Spain

Abstract

Nowadays, creativity is a key aspect in education and a pillar in the STEAM framework. STEAM adopts an integrative approach to knowledge and disciplines. Accordingly, creativity can be understood in a comprehensive manner that encompasses various forms (artistic, scientific, artisan) and conative aspects. Therefore, science education should also focus on promoting creativity, especially in primary education, where it is developed in connection with other disciplines. This study aims to analyse how students participating in a STEAM project for primary education perceive their own development of creativity and the relationships between these aspects. The project involves scientific, mathematic, artistic, technological, and engineering activities, all connected by the theme of the Egyptian civilisation, and culminates in a transdisciplinary project to build a temple. 109 students aged 9-11 participated. A questionnaire validated by experts was used. The results indicate that the students reported a high development of their creative self-concept in terms of perceiving themselves as having acted as engineers, scientists, mathematicians, and artists. They also emphasized the opportunities to generate ideas and solutions by creating new and functional objects. These diverse aspects of creativity show significant correlations between almost all of them, reinforcing the idea that STEAM projects, based on connected activities with a common theme and ending with a transdisciplinary project, enhance a multidimensional and integrated development of creativity.

1069 Facilitating Networked Science Education Leadership to Promote an Open and Sustainable School Culture

Tina Maria Brinks, Gitte Miller Balslev

University of Southern Denmark, Odense, Denmark

Abstract

Science education has over the past years gained a growing focus and plays an important role in school development especially regarding education for sustainability. This paper asks how educational leadership can facilitate a sustainable, collaborative school culture at different levels of the educational system. We build on the Danish national centre of NAFA as well as a new case study from 2022 of a science program in the lower secondary education in a Danish

public school, which indicate that aspects such as trust and equity are important for the perception of the facilitation of collaboration. We argue that science education leadership is equally complex and important in facilitating meaningful collaboration, to create student-centered learning. With this paper we seek to add to the research field of science education leadership by offering perspectives on what sustainable leadership could look like going forward to strengthen school collaboration and students' learning.

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510 Monitoring Brain Waves During the Implementation of Digital STEM-Based Practices

Cagla Bulut Ates, Hilal Aktamış, Furkan Aydin

Aydin Adnan Menderes University, Aydin, Turkey

Abstract

It is seen that, with the emergence of novel technological solutions, there is a tendency towards brain-oriented research in various fields from art to business. The field of education has been included to those as educational researchers initiated to construct research designs through monitoring brain activity. It is aimed that investigating the dynamics of brain during the learning process can contribute to the creation of the instructional design. Likewise, in this study, students' brain waves were targeted to be examined to find out the effects of an e-learning environment designed with STEM activities. The educational modules developed via google forms were implemented to 6 middle school students at the 6th and 7th grade level. During implementations, brain waves of students were monitored and recorded through EEG method. As data collection tool, a wireless commercial EEG headset was selected in terms of functional and practical purposes. A data recording software simultaneously recorded brain wave data throughout whole process. From the obtained data, alpha frequency band, which is related to creativity skills, was analyzed and the relationship between STEM based activities and increase in amplitude at this frequency band was investigated. According to the results, it demonstrates that product design and project idea development parts of the modules have positive effect on increasing students' creativity skills. Nevertheless, the effect of developed STEM activities can be further examined by implementing in real classroom environment in order to compare and contrast of e-learning and traditional learning settings.

Parallel Session - 8.11 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Diego Navarro

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805 An International Perspective on STEM: How Private School Teachers Conceptualize the STEM Education Approach

Rıdvan Elmas[1], Nur Cengiz[2], Merve Adiguzel Ulutas[3], Murat Akarsu[4], Sedef Canbazoglu Bilici[3]

[1]Afyon Kocatepe University, Afyon, Turkey. [2]Yıldız Teknik University, Istanbul, Turkey. [3]Gazi University, Ankara, Turkey. [4]Agrı Ibrahim Cecen University, Agrı, Turkey

Abstract

This study reports teachers' definitions of STEM and examines their awareness regarding the features of the STEM education approach considering regional variations. This study is descriptive in nature for pursuing the general definition and characteristics of the STEM Education Approach. The sample consisted of 522 teachers actively working in private schools in different parts of the world. There are various conceptualizations in the definition of the STEM education approach depending on the teachers and regional contexts besides most frequent characteristics mentioned in the findings are being interdisciplinary, based on daily life contexts, and their relation to 21st Century the skills.

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851 Opinions of Pre-Service Science Teachers on Interdisciplinary Science Teaching

Özge Çiçek Şentürk

Kilis 7 Aralik University, Kilis, Turkey

Abstract

Science teachers guide secondary school students to establish interdisciplinary relationships. Therefore, teachers need to be informed about interdisciplinary teaching starting from their undergraduate education. The "interdisciplinary science teaching" course was added to the fourth grade of the science teacher training program, which was updated in the 2018-2019 academic year in Turkey. It is important to determine the views of these pre-service science teachers, who will establish interdisciplinary relations after starting teaching, about interdisciplinary science teaching. This research aims to reveal the views of senior pre-service science teachers about interdisciplinary science teaching.The following research questions guided this study:

1. How did pre-service science teachers define interdisciplinary science teaching?
2. What are the advantages and disadvantages of interdisciplinary science teaching according to pre-service science teachers?

3. According to pre-service science teachers, which science subjects are mostly used in interdisciplinary science teaching?

This study was designed with a case study. The participants of the study were seventeen senior pre-service science teachers. Data were collected from pre-service teachers through semi-structured interviews. The themes obtained from the analysis of the data are as follows: "defining interdisciplinary science teaching", "strengths of interdisciplinary science teaching", "challenges of interdisciplinary science teaching", and "science subjects with the most interdisciplinary relations". While describing interdisciplinary science teaching, pre-service teachers used the expressions "associating science with engineering, mathematics, and technology, integrating science disciplines with different disciplines, transferring the knowledge of one discipline to another discipline". According to them, interdisciplinary science teaching is mostly used in teaching the subjects of heredity, pressure, periodic system, and cell divisions. They also stated that it is difficult to integrate different disciplines, although it develops higher-order thinking skills.

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925 The Nature-Knowledge-Values Framework: A Transdisciplinary Approach to Nature of Science Teaching and Learning

Klaus Colanero

The Chinese University of Hong Kong, Hong Kong, China

Abstract

The Nature-Knowledge-Values (NKV) approach is based on the reasonable heuristic assumption that all problems can be analysed comprehensively from the point of view of three fundamental aspects and their interplay: (1) people's beliefs or assumptions about nature (Nature), (2) human knowledge (Knowledge), and (3) human values (Values). The three key aspects and their six possible mutual relationships constitute a thinking framework (NKV framework) aimed at aiding teachers and students to disentangle problems and to identify main issues, with the intent of shedding light on their complexity without artificially simplifying them. More specifically the NKV approach provides a conceptual contextualization of science education, particularly of the various NOS aspects proposed in the related literature (Clough, 2017; McComas, 2020; Taber, 2017a). The talk will focus on how the NKV framework has allowed the author to develop a set of probing questions to identify which fundamental concepts and issues of NOS are more challenging for students in the context of a tertiary education core curriculum course. Findings from a set of "Surveys for learning" will be presented and discussed together with preliminary teaching interventions to address the corresponding learning needs.

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940 Trust, Democracy and Expert Systems: The Perception of Science Teachers

Diego Navarro, Mauricio Pietrocola

University of Sao Paulo, São Paulo, São Paulo, Brazil

Abstract

The present study aims to map the perception of science teachers regarding an expert system in the context of the 2022 Brazilian presidential elections. A sample of 16 science teachers was investigated and they responded to a questionnaire using the Free Word Association. To choose an inducer to the technique, 46 headlines of traditional media were used to create a word cloud. From the word could, the inducer "electronic voting machine" was chosen and the teachers produced a total of 80 terms. The terms were analyzed by the IRAMuTEeQ software and a graph was produced to represent how the terms could be related. It is noticeable the implied trust the teachers have in the expert system, reassuring the position of the expert system itself. Also, it is implied a link between a strong democracy and technology as guarantee of rights.

Parallel Session - 8.12 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Marcelo Tadeu Motokane

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530 Climate Education With Systems Thinking: How Well Students' Explanations Match With the Systems Model

Meltem Ceylan Alibeyoglu[1], Zeynep Işılay Başkahya[1], Gaye D. Ceyhan[2], Sena Yıldız Değirmenci[3], Nihal Güneş Demir[4], Saadet Etli[5], Görkem Girgin[1], Emre Göktepe[6], Büşra Karga[4], Ece Ünsal[1], Ulkem Yararbas[7]

[1]Darussafaka Middle School, Istanbul, Turkey. [2]Bogazici University, Istanbul, Turkey. [3]Technical University of Munich, Istanbul, Germany. [4]Hisar Middle School, Istanbul, Turkey. [5]Terakki Foundation Schools, Istanbul, Turkey. [6]Sistems Thinking Association, Izmır, Turkey. [7]Ege University, Izmır, Turkey

Abstract

Today, the climate crisis is one of the most critical factors threatening the ecological balance. Using the systems thinking approach in climate education is essential to develop students' scientific thinking and problem-solving skills in relation to dynamic environmental issues. For this reason, this project, supported by the UNDP Acceleration Lab, aimed to provide students with a learning experience where they can understand the structure and functioning of the climate system and a simulation environment where they can take a decision-making position in policy development. The project was a 10-week climate education program delivered as an

after-school activity with nineteen volunteer 8th-grade students. As part of the project, this case study aimed to explore the extent to which the model used in the education program overlapped with the students' explanations after the implementation of the program. Semi-structured individual interviews at the end of the program were used as a data collection tool and analysed using the thematic content analysis method. The researchers independently examined which elements of the system model used in the program corresponded to the answers given by the students in the individual interviews and how often they were used. Among the main elements of the model, the economy was the most frequently mentioned category (53%), followed by the carbon cycle (31%). Population and the greenhouse effect were the least frequently mentioned. It is noteworthy that human population and economy were mentioned in addition to anthropogenic emissions as they are crucial to understanding human-induced climate change. Overall, the study provides valuable insights into the effectiveness of using the systems thinking approach in climate education and its impact on students' understanding of the complexity and dynamics of the climate system. The study also highlights the importance of considering the economy and population as key factors in understanding the climate crisis.

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771 Integrating Socio-Scientific Issues Into Context-Based Learning: Chemistry Teachers' Perspective

Antuni Wiyarsi, Nur Fitriyana, Metridewi Primastuti

Yogyakarta State University, Yogyakarta, Indonesia

Abstract

Linking the chemistry content knowledge within certain context through the use of Context Based Socioscientific Issues Learning (CBSIL) is needed to address the irrelevance of chemistry concepts with its wide application. The chemistry teachers must have sufficient skills in designing such pedagogy to provide meaningful chemistry learning for their students. This research aimed to explore ISCTs' experiences, efforts, opinion, expectation, and knowledge in designing their chemistry lesson. A descriptive study with survey methods was introduced in this research. There are 32 experienced chemistry teacher that were participated in the data collection process using Chemistry Teachers' Perspective Questions (CTPQ) that covers 5 themes namely: (1) efforts to increase students' understanding towards chemistry, (2) how chemistry subject should be taught vs present strategy that given by ISCTs, (3) how to increase chemistry learning activities quality, (4) chemistry teacher's expectation towards chemistry learning, and (5) Chemistry teachers' knowledge about CBSIL. Content analysis was employed in the data analysis. It was revealed that the chemistry teachers not only need teaching experience but also need to have sufficient competencies to design meaningful CBSIL. Therefore, cultivating chemistry teacher Pedagogical content knowledge (PCK) is needed to design specific learning frameworks in certain chemistry concepts.

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798 Argumentation-Based Inquiry Teaching for Developing Scientific Literacy

Günkut Mesci[1], Funda Yeşildag-Hasançebi[1], Eda Erdas-Kartal[2]

[1]Giresun University, Giresun, Turkey. [2]Kastamonu University, Kastamonu, Turkey

Abstract

The purpose of this study is to develop pre-service teachers' science literacy skills through argumentation-based inquiry activities. In this study, one group pretest-posttest experimental design was used. Participants of the study were 25 pre-service science teachers (PSTs) who were enrolled in a public university located in East Black Sea region of Turkey. This study was carried out within the scope of the "Science Teaching and Laboratory Practices" course, which was a semester course (14 weeks) taking place 3 hours a week. This course was based on the experimental teaching of a science subject in a science laboratory every week. The data of the study were collected using the "Scientific Literacy Scale". Based on the assumption of normality, dependent sample t-test was used for the analysis of the data. As a result of the analysis, it was determined that the PSTs' pre-test and post-test averages significantly differed in favor of the post-test. As a result of the findings, PSTs' scientific literacy skills have significantly improved after the implementation.

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913 Between Names: A Semantic Study on the Common Names of the Açaí Fruit (*Euterpe Oleracea* Mart)

Felipe Paulino Ramos, Marcelo Tadeu Motokane

Universidade de São Paulo, Ribeirão Preto, São Paulo, Brazil

Abstract

Scientific names for the identification of species have been adopted by different human civilizations for centuries. However, common names are used extensively, composing traditional knowledge. These terms can originate from physical attributes, species' locations, and folklore. Comprehending the meanings behind these words used to name species are useful to potentialize Biology Teaching. Thus, the objective of this work is to analyze the synonymy of the common names of the açaí (*Euterpe oleracea* Mart.), a species of economic importance and valued by native people and traditional communities, with emphasis on semantic study. The main classes of associations of synonymous terms for the word *"açaí"* are related to its botanical classification, its places of occurrence, and to indigenous languages. In this context, understanding the meaning of common names is to value traditional botanical knowledge. The semantic analysis of common plant names enables the mitigation of the "plant awareness disparity" in education. This happens through a contextualization of the content to the particular experiences of each student, which promotes an effective Botany teaching, in order to create an enchantment for the plant world. The results obtained also show that linguistics can contribute to a meaningful learning of scientific vocabulary, by building networks of meanings of terms and proposing reflections about the formation of words. Finally, we

emphasize the need for a science teacher education that takes into consideration the education of language teachers.

Parallel Session - 8.13 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Valentina Pivotti

966 Sustainable Development Goal-13 (SDG-13): Awareness Beliefs and Pro-Environmental Behaviour Among High-Schoolers in Israel Regrading Climate Change

Ahmad Basheer, Naji Kortam, Firas Hiadre

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Abstract

The issue of climate change and global warming is one of the most sensitive difficulties facing the world in general, including the state of Israel. This issue is getting more complicated over the years and with industrial and technological advancement. This study focus on the 13th goal, of the 17 SDGs (Sustainable Development Goals) declared by the United Nations Assembly. 360 high school students from Northern and Central Israel participated in the survey, 237 females and 123 males. 139 (38.6%) Environmental Science Students and 221 (61.4%) students from other majors (chemistry, biology, physics, and biotechnology). The findings of this study indicate that the extent of awareness of climate change among the students in all majors is close, Environmental Science Students (46.76) and the other majors (46.89). Also, we infer that about 50% of the Environmental Science students have acquired their knowledge about global warming from school, while 48% of the other majors' students have acquired it from external sources and school. There is also no difference in the extent of belief among Environmental Science students and the other majors. The high-schoolers from all majors have shown a moderate to a reasonable extent of belief in their ability to decrease the climate change effects by adopting a better behaviour towards environmental issues. Additionally, there is a positive relationship between the extent of awareness and the pro-environmental behaviour and based on the values of the coefficient, beliefs (0.877) and awareness (0.061). Thus, we can conclude that beliefs have a significant impact on pro-environmental behaviour. Regarding gender dependence, there is a distinct difference between the three indicators: awareness, beliefs, and pro-environmental behaviour in favour of females compared to males.

961 After the Project Ends: The Transformational Potential of Open Schooling Project

Katarzyna Potega vel Zabik[1], Tamar Fuhrmann[2]

[1]Copernicus Science Centre, Warsaw, Mazovia, Poland. [2]Teachers College, Columbia, University, New York, New York, USA

Abstract

The aim of this paper is to show potential areas of impact of the Open Schooling project on the community of learners. This project aims to support schools in implementing a sustainable Open Schooling model for education. The project focuses on running activities where children solve challenges in and with the community using tools and approaches from the maker education movement. It proposes a practical instructional framework to develop learners' knowledge, skills, and character, which are needed in the 21st century to become successful in the world. In addition, the project offers support, professional development, and training for teachers. Results illustrate changes observed by teachers in the following dimensions: individual (student), classroom dynamics, and systemic.

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347 The Relationship Between Robotic Assisted Sustainable Green Transformation and STEAM Approach

Nejmettin Yildirim[1], Tuba Güler[2]

[1]Darende Osman Hulusi Ateş İ.H.O, Malatya, Darende, Turkey. [2]Kayapinar Bilim Ve Sanat Merkezi, Diyarbakir, Kayapinar, Turkey

Abstract

The aim of this study is to reveal the views of science, mathematics, technology design, informatics teachers about Robotic supported STEAM and Green environment sustainability supported STEAM based course activities. The study was carried out in descriptive design, which is one of the qualitative research methods. Fifteen teachers working in state, private and BİLSEM in different provinces participated in the research. Tenof the participants are female and 5 are male teachers. In the study, data were collected in 10 days using a semi-structured questionnaire. The collected data were analyzed by content analysis. As a result of the applied questionnaires, it was shown that the teachers associated the Robotic supported STEAM-based activities and the STEAM-based activities supported by sustainable green practices with their fields and found them suitable for environmental problems. It was stated that they constructed the relationship between science, technology, engineering, mathematics and culture in their courses. In addition, it was stated that many acquisitions are suitable for environmental sustainability and cultural heritage in out-of-school environments. According to the results obtained; It has been observed that there is no clear distinction between teacher education level, school type or seniority year in robotic-assisted STEAM-supported STEAM-based course activities and sustainable green practices, and most teachers are aware of this issue. In addition, in order to increase the sustainability of this study, a project was created with the participating

teachers after this study and lesson plans were created by ensuring the active implementation of the study.

230 Identity as Performance, Recognition and Competence when Facing Environmental Wicked Problems in Middle School

Valentina Pivotti

Malmö University, Malmö, Sweden

Abstract

Environmental wicked problems (EWP), characterized by incomplete knowledge and a widespread lack of agreement on how to address them, are becoming part of our everyday decisions (Should I buy ecologic food even though it costs twice as much?), news feed (e.g. droughts in Ethiopia and floods in Pakistan), and geopolitical tensions (e.g. the EU dependency on Russian natural gas). As young citizens face such EWP in their school as well as private life, how are they making sense of these complexities? How do they relate to the terms of the ongoing conversations? Are they negotiating such terms? To investigate these questions among others, I turn to what identity can mean in this context of EWP. I therefore draft an initial conceptualization of a EWP identity by working along the lines of the threefold science identity model of performance, recognition and competence. In particular, I characterize the three aforementioned dimensions by analyzing a series of workshops where middle-school students encountered specific EWP through instances of process drama. Throughout the workshops, I identify instances when students reveal competences to navigate the EWP-specific complexities; and moments when students perform in ways that respond to EWP-specific challenges; and see how they give and receive recognition for being someone who can handle EWP.

Parallel Session - 8.14 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Tawinan Saengkhattiya

51 Design Fiction in Engineering Education: Imaging Waste Management in Different Futures

Nicolas Hervé[1,2], Julitte Huez[3,2]

[1]ENSFEA, Toulouse, France. [2]Université de Toulouse, Toulouse, France. [3]INP-ENSIACET, Toulouse, France

Abstract

Our communication deals with the experimentation of a training module in engineering education based on design fiction. It aims at problematizing the theme of waste by making groups of engineering students think about different climatic and technological futures. The analysis of the written productions shows that the pedagogical device allows students to generate different technical schemes of waste management that are thought in their social inscription. Articulating the temporalities of technological and climatic processes, and understanding low-tech appear to be two challenges for perfecting the training module.

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500 Game-Based Learning in Environmental and Sustainability Education

Luana Silveri, Mita Drius

Free University of Bozen, Bozen, Italy

Abstract

Game-based learning (GBL) is a didactic approach which fully integrates game characteristics with instructional content. It can provide a rich learning context to help learners construct higher-level knowledge and create immersive and engaging environments. It stimulates cognitive and emotional involvement, which are critical in deep learning. Games can play an especially prominent role in the university context; they can be used to vehiculate content knowledge in many different disciplines by promoting cognitive skills and competencies such as communication, collaboration, or problem-solving. However, a lack of integration between gaming and teaching and a poor balance between enjoyment and education could undermine the efficacy of GBL in higher education. In this paper, we show a preliminary case study, where the game "YouTopia – the ecosystem valley", a board game on ecosystem functioning, was implemented involving 24 students of the Master's degree course in Primary Education at the Free University of Bolzano – Bozen (Italy). This case study was implemented to understand how students of Educational Sciences perceive a board game as a teaching tool for acquiring knowledge about ecosystem functioning, especially considering their limited background in ecology. Students played the board game and were then asked to fill out a short questionnaire to elicit their perception regarding the board game's playability, engagement, didactic value and general appreciation. According to the questionnaire results, most students enjoyed the experience and were stimulated to boost skills such as critical thinking, argumentation, and problem-solving. One-third of the students, however, did not perceive to have acquired new knowledge or to have modified their beliefs. The efficacy of the proposed approach as a first hint to activate students in ecology issues is also discussed. The preliminary results encourage further on-field tests, and the development of other GBL units focused on other scientific topics.

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520 Gifted Student's Drawings of Present and Future Science Classroom Environments

Ayçin Ünal[1], İsmail Dönmez[2,3], Antti Laherto[2]

[1]Università degli Studi di Udine, Udine, Italy. [2]University of Helsinki, Helsinki, Finland. [3]Muş Alparslan University, Mus, Turkey

Abstract

This case study aims to explore the perceptions of gifted students towards science learning environments in the present and in the future. The participants were 80 students between the 2nd and 7th grades who attended an institution that provides education for the gifted students. The method of "Kinetic School Drawings (KSD)" was used to evaluate the students' drawings. Two science education experts analyzed the drawings. The results show that in students' drawings on the present science learning environment they portrayed themselves in a traditional classroom environment or laboratory, doing academic practices or experimentation under the supervision of their teachers. In future classroom drawings, the students portrayed themselves in a non-traditional learning environment (futuristic) and independent of the location. While describing learning behavior in their drawings, they emphasized learning with technology. They also tended to use robots/artificial intelligence for teachers, VR glasses, and mobile apps for learning. The study showed that thinking and imagining alternative futures is a difficult process, but it can help design a learning environment for the gifted in the future.

1235 Perception of Gifted Science Students Toward STEM Problem-Solving Interventions Regarding Environmental Sustainability Issue

Tawinan Saengkhattiya, Mike Watts, Sarmin Hossain

Brunel University London, London, United Kingdom

Abstract

Young Engineers for a Sustainable Future (YES!) is a one-day programme constructed as part of my PhD research regarding integrating education for sustainable development through STEM education. As an enrichment pedagogical activity to be applied at the primary school level, it has aimed to promote gifted science students in Thailand in learning problem-solving skills, collaboration, and knowledge for sustainable development. Based on a specific conceptual framework involving Thailand's science standards and the United Nations' Sustainable Development Goals (SDGs), the programme provided knowledge about environmental sustainability issues, including landslides, floods, droughts, and plastic waste in rivers and oceans. The programme employed a STEM problem-solving process that embedded different elements of Engineering Habits of Mind (EhoM) to help learners practice engineering problem-solving skills and invent innovative artefacts within problem-solving strategies. The intervention was delivered in eight science and mathematics gifted classrooms in seven primary schools around Thailand, where 258 students (year 4 – 6) and 14 teachers were involved. After participating in the programme, where data were collected from both teachers and students as

part of phase 1 data collection, this study was also conducted as part of phase 2 data collection to see the students' perceptions of the programme in several aspects. Twelve open-ended questions were asked, and forty students were written to answer one of the questions each week in the diary and finish the whole diary within three months from the day of participation. Thematic analysis was used to analyse the students' writing to see what they perceived about the intervention, the issues that concerned them the most, how they could help solve those environmental sustainability issues by themselves and their community, and their perceptions about the SDGs they had learned.

Parallel Session - 8.15 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Renata Ryplova

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365 Adolescents' Knowledge and Attitudes Toward Pollinators: Implications for Conservation

Rita Hagevik[1], Kathy Cabe Trundle[2], Katherine Vela[3], Laura Wheeler[2], Michelle Parslow[4]

[1]UNC-Pembroke, Pembroke, NC, USA. [2]Utah State University, Logan, Utah, USA. [3]Utah State University-Eastern, Price, Utah, USA. [4]Wahlquist Junior High School, Farr West, Utah, USA

Abstract

This research examined adolescents' knowledge and attitudes about pollinators, specifically bees, and attitudes toward protecting them. Recent studies focused on adults' understanding of pollinator conservation, but less is known about adolescents' views. This research is important because we conserve what we value. Pollinator abundance and diversity are declining worldwide, and they are critical to the ecology and economy of our world. To inform conservation efforts, we designed, validated, and administered a survey to examine the experiences, knowledge, and attitudes of adolescents toward pollinators. We found that 98% of participants overestimated the number of species of honeybees and 100% underestimated the number of native bee species. Yet overwhelmingly the participants expressed a strong desire to protect bees and pollinators in general. Native bees were often misidentified, and aggressive wasps were often confused with bees. Yellow and black coloration may have caused misidentification of native bees, and only 35% of participants correctly identified a honeybee, most often confusing it with a bumblebee. Insect biodiversity is essential for healthy ecosystem functioning. Our results call for efforts to help adolescents learn about and care for pollinators while connecting them to broader conservation efforts.

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377 The Use of Folktales in Elementary School Science: Students' Understanding of Folktales at the Teacher Training Stage

Karen Onodera[1], Hiroki Fujii[2]

[1]Kyoto Koka Women's University, Kyoto, Japan. [2]Okayama University, Okayama, Japan

Abstract

In this study, to devise a course at the teacher training stage that makes use of folktales from various regions that express the wisdom and ideas of our ancestors regarding coexistence with nature, a questionnaire survey was conducted to ascertain to what extent students were able to grasp our ancestors' views on nature, especially the idea of coexistence between nature and humans, as seen in the folktales. Of the 45 students surveyed, about one-third were able to grasp their ancestors' ideas about the coexistence of nature and humans from the folktales, such as 'It is impossible for humans to live alone, and life depends on other life forms'. The contents of the ideas were varied and included many viewpoints about the coexistence between rivers and humans today. If we can devise lessons for the teacher training stage based on these students' perceptions, the use of folktales in science and integrated learning will be realistic and attractive to students.

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399 Students' Understanding of the Greenhouse Effect: A Cross-Age Study

Ceren Özçelik, Emine Adadan

Boğaziçi University, Istanbul, -, Turkey

Abstract

This study investigated students' mental models of the greenhouse effect at different grade levels (Grade 9, Grade 11, and the pre-service teachers). Thus, the study identified the components and properties of the mental models of each participant about the greenhouse effect and explored how the main constituents of these models progressed across different grade levels. Individual interviews were conducted with high school students: Grade 9 (n=18) aged between 14-16, Grade 11 (n=24) aged between 17-19, and pre-service physics and chemistry teachers (n=19), who were 18-29 years old. This study used qualitative data from semi-structured interviews and sketches to identify the participants' mental models about the greenhouse effect. The constant comparative method was used to analyze student answers to questions about the greenhouse effect. The features of greenhouse effect mechanisms and ten different mental models were identified. The Macro Models without particulate level explanations outnumbered the Micro Models in which the properties of particles are explained, across all participant groups. The pre-service teachers have more frequently exhibited a scientific mental model about the greenhouse effect compared to the other groups. Alternative conceptions of the students about the greenhouse effect were also identified and compared across the groups.

1060 Plant Role in Solar Energy Distribution in the Landscape as a STEM-Oriented Topic of Environmental Education

Renata Ryplova[1], Jan Pokorny[2]

[1]University of South Bohemia in Ceske Budejovice, Ceske Budejovice, Czech Republic. [2]ENKI, o.p.s., Trebon, Czech Republic

Abstract

Plant blindness, longstanding phenomenon describing human ignorance of plants together with its consequence, plant illiteracy, i.e. poor understanding of plants are significant barriers for sustainable development. On the other hand, the EU New Green Deal policy based among others on the use of plant biomass as one of the renewable energy sources requires active involvement of general public. From these reasons, effective environmental education of broad public delivering correct information on the solar energy use by plant biomass is necessary. Unfortunately, just limited information about the level of general public knowledge of the solar energy use by vegetation is available. This contribution brings results of a survey based on pre/post - test experimental design done among secondary school students in Czech Republic. The aim of the research was to discover students' conceptions of plant role in solar energy distribution in the landscape and an impact of STEM-oriented teaching activity on these conceptions. Results of the pre-test indicated significant student misconceptions: As the main process by which vegetation utilizes solar energy photosynthesis instead of transpiration was considered and the amount of solar energy utilized by plants in photosynthesis was overestimated. Principles of heat energy dissipation by evapotranspiration and by this way cooling of local climate by vegetation were not familiar to students. Students have neither correct idea of annual plant biomass production per square meter, nor the amount of plant biomass necessary for the energy supply of their household and the land area necessary for the production of this biomass. Student attitudes to plants before the intervention supported the theory of plant blindness. The plants were considered as not much important (mean value 2.3 from 5point scale). After the intervention, significant improvement of student knowledge as well as student conceptions of the plant significance was detected.

Parallel Session - 8.16 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: So Yeon Park

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26 Between the Lines of Natural and Cultural Heritage: A Case Study of a Science Museum Field Trip Plan

Jung Hua Yeh

National Museum of Natural Science, Taichung City, Taiwan

Abstract

Field trips can enhance student's life experience and motivate them to learn. This study explored how the National Museum of Natural Science (NMNS) in Taichung, Taiwan, acts as field trip collaborator to devise field trip plans with schools and domestic community organizations to promote elementary school students' awareness of the relationships between humans, nature, and conservation efforts while experiencing natural heritage. A total of 18 elementary schools have participated in this project. The schools expect that the NMNS can organize a field trip plan incorporating reflective thinking about humans and nature rather than offering a simple guided tour of the fossil layer. The present study applied the sociocultural approach to analyze the formulation of a field trip plan and determine how the museum collaborates with domestic community organizations to encourage the interpretation of local culture and natural heritage and how the museum cooperates with partner schools to refine the teaching plan of a field trip. From March 16 to May 11, 2021, 227 students attended the aforementioned field trip. An analysis of students' posttrip journals revealed that the students had strong interactions with people in local community, but few students gained an awareness of the relationship between humans and nature. Following the participant schools' suggestion, the coastal path guided tour was replaced with an on-site hands-on activity at a colonial-period abandoned tunnel and fossil outcrop. All such events were halted because of the COVID-19 pandemic for five month. When they resumed, 391 students participated in the updated field trip between September 28 and October 26, 2021. The students' feedbacks revealed that the students noticed the changes to the landscape made by past and contemporary people. Postpractice reflections were discussed, and models relating to regional resources, science museums, and schools establishing in outdoor science education were proposed.

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48 Minority Students Learning in Informal Environments: Views of Leading Administrators

Tali Tal[1], Maha Jaramne[1], Abeer Watted[2]

[1]Technion, Haifa, Israel. [2]Al-Qasemi Acasemic College, Baqa-El-Gharbia, Israel

Abstract

The study focuses on the reasons for limited use of out-of-school science learning (OoSL) in the Arab society of Israel, which makes 21% of the country population. We investigated views of OoSL of senior officials from the Ministry of Education and examined whether the issues they raised are manifested in field trips. We interviewed nine senior officials and observed 10 field trips to various informal environments, but due to brevity only four interviews and two field trips are presented here. We found high consensus among the administrators regarding obstacles: low awareness of the importance of OoSL among teachers, principals and parents and insufficient teacher education that emphasizes the importance of OoSL and provide support for teachers and insufficient financial resources. Yet cultural issues were addressed as the main reason for under use of OoSL by the school system. Data from two field trips demonstrate excellent vs. mediocre implementations. The reasons for the difference can be associated with

lack of training of teachers and informal educators, limited communication in many settings, like the science center and with the importance of developing what our interviewees termed "field trip culture". These findings can be interpreted through the cultural style approach to argue that the science center does not pay attention to different cultural styles. We suggest that adopting this approach could better support educators in the Arab society to implement OoSL.

735 Students' Opinions on the University Community's Sky Observation Activity as an Out-of-School Learning Environment

Uygar Kanlı[1], Nuray Önder Çelikkanlı[2]

[1]Gazi University Faculty of Education, Ankara, Turkey. [2]Gazi University Facult of Education, Ankara, Turkey

Abstract

This study aims to reveal students' opinions on the university community's Sky Observation Activity (SOA) as an out-of-school learning environment. In this research, the survey method was used to determine the students' opinions on the SOA. This activity includes Lunar-Jupiter-Saturn observations and it was conducted outside of school hours. 66 university students from different disciplines who participated in the SOA, voluntarily. The top five reasons of students for participating in the activity are: to be interested in the activity, learning about Lunar-Jupiter-Saturn, having a good time, improving themselves, and socializing. SOA made various positive contributions to students such as having a good time (80%), being informed about Lunar-Jupiter-Saturn (76%), and understanding the importance of participating in social activities (39%), etc. In addition, all students' satisfaction levels with the activity were over the medium. Thus, such types of out-of-school activities could be a part of formal learning.

827 Re-Thinking Cultural Border Crossing: Cultures Of Academia and Local Government for STEM Education

So Yeon Park, Jinwoong Song

Seoul National University, Seoul, Korea, Republic of

Abstract

Contemporary research on concepts of cultural border crossing has focused on students and teachers at classroom level. However, as science education is not bound to formal education only and more diverse actors emerge to play their roles for informal STEM education, broader concept of cultures in science education needs to be studied. This research aims to explore how two distinct cultures, academia and local government, have demonstrated cultural border crossing for a four-month informal STEM education through local government-university partnership in Korea. Cultural border crossings were observed in four domains: 1) orientations of the program, 2) physical resources for STEM education, 3) application process, and 4) administrative process. The two cultures have smoothly negotiated values, beliefs, expectations

and conventional actions in terms of orientation and application process. These smooth transitions were significantly influenced by the university culture due to local government's acknowledgement for expertise in STEM education in the counterpart culture as well as sufficient time for discussion in the planning phase. When the program was implemented, both cultures prioritized the delivery of quality STEM education smoothly which led both cultures to compromise physical resources when problems of the educational zone emerged. Not all observed domains were negotiated or compromised. The issue of differences in fiscal year in two cultures becomes burdensome to administrative work and results in decreased efficiency, but culture of the local government perceives negotiating fiscal year is utterly impossible. The significance of the study lies in rethinking the concept of 'cultures' beyond classroom, to provide insights how diverse actors could take part to provide informal STEM education and implications for the practice of informal STEM education through local government-university partnership.

Parallel Session - 8.17 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Nurazidawati Mohamad Arsad

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615 Biking to Transgress Boundaries: Transforming Pre-Service Science Teachers Critical Consciousness

Noemi Waight[1], Jennifer Tripp[2], Sarah Robert[1], Ryan Rish[1], Monica Miles[3]

[1]University at Buffalo, Buffalo, NY, USA. [2]Buffalo Public Schools, Buffalo, Ny, USA. [3]Teachers College Columbia, New York City, NY, USA

Abstract

This study documented Pre-service Teachers (PSTs) written pre and post bike ride reflections related to (a) science and associated resources in the community, (b) how science in the community is reflected in the standards, (c) what PSTs know about the history and culture of their community where they and their prospective students live, (d) and the shifts in their critical consciousness. A social design approach guided this study; the main data sources were pre and post bike ride reflections and images and materials collected during the ride. The findings revealed an important shift, a sense of "seeing" and critical exposure that transformed PSTs' awareness of science teaching-learning-community connections, and equity and social justice with pre- and post- bike ride reflections. This study has implications for understanding community-based, historical, and cultural science teaching and learning and envisioning alternative experiences and exposures to transgress boundaries and deepen critical consciousness in teacher education.

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781 Contextual Influences on Teacher Turnover: Attrition & Inequitable Science Learning Conditions

John Settlage, Ben Wasserman

UConn, Storrs, Connecticut, USA

Abstract

Recognizing that the quality of science education a school can provide to its students is reduced when there is continual loss of science teachers, this study examines the relationships between school level factors and the rapidity of science teacher attrition. Teacher attrition is increasingly recognized as a major source of learning inequities. Following an ordination process that measured the degree of similarity and dissimilarity across all high schools within one state, we identified measures for their relative contribution to interschool variability. Then, those measures were compared to variation in the attrition of science teachers. It was found that viewing schools as socio-ecological systems was an effective means for describing inequitable patterns in science teacher turnover. These results revealed malleable school factors that are malleable that, if offer adjusted, could reduce science teacher departures. Applied to schools suffering from high science teacher attrition, stability in staffing and program continuity, could elevate academic outcomes and contribute to realizing efforts to reduce intergroup achievement gaps in science.

1086 Fixing the "Leaky Pipeline" or 'Fixing Physics?': The Experiences That Encourage Women to Study Physics

Judith Hillier

University of Oxford, Oxford, United Kingdom

Abstract

In many countries, women are still under-represented in physics, despite many initiatives to encourage more women to study and work in physics. This study examines the experiences of 900 women and non-binary physics undergraduates from the UK and Ireland who applied to and attended conferences held annually from 2015-2023, with approximately 100 participants each year. Pre and post conference questionnaires were used to gather data on their educational and family backgrounds, their experiences so far of studying physics and their career aspirations. The majority did not have physics in their family background, but were encouraged to study physics by their physics teachers and their parents. The participants reported mixed experiences with their peer groups, receiving both support and encouragement, but also experiencing microaggressions and sexist stereotypes, feeling devalued and ignored, and suffering a lack of female role models. The experiences of the participants at the conferences changed both their self-concept beliefs about being physicists, and their self-efficacy beliefs about succeeding in physics. These findings demonstrate that it is possible to create an inclusive culture in physics, suggesting that changing the culture of university physics departments – "fixing physics" – has more potential to create a gender

equitable subject than previous attempts to "fix the women".

1119 A Science Instructional Design Based on Funds of Knowledge Approach for Semai Children

Nurazidawati Mohamad Arsad[1], Azizah Osman[1], Wan Nor Fadzilah Wan Husin[2], Marlissa Omar[1], Zanaton H Iksan[1], Rubaaiah Sidek[3], Lilia Halim[1]

[1]universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia. [2]Curriculum Development Division, Ministry of Education, Malaysia, Putrajaya, Malaysia. [3]Curriculum Development Division, Ministry of Education, Malaysia, PUTRAJAYA, Malaysia

Abstract

The transformation of education for indigenous (Orang Asli) children aims to provide educational opportunities in science learning that are relevant to their needs and consistent with mainstream education, as well as enhance Orang Asli children's equitable access to high-quality education. As a result, for the well-being of Orang Asli children, particularly those from the Semai ethnic subgroup, it is critical to provide teachers with the Funds of Knowledge (FoK) approach, which enables them to understand Orang Asli children's lives in the context of their cultural background and serves as a bridge between science learning and children's FoK. Using 5E constructivist learning cycle as a fundamental instructional model that integrates FoK, we work collaboratively with science and language teachers and Semai ethnic children at two different Orang Asli schools to develop an intervention for teaching and learning. This study focuses on the importance of culturally responsive science pedagogy (CRSP) for indigenous groups, where people's culture does not stop them from learning science but instead helps them learn.

Parallel Session - 8.18 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Takuya Matsuura

488 Towards Social Justice: How Youth-Led Transformation in a Regional Science Centre

Wisam Sedawi[1], Angela Calabrese Barton[1], Micaela Balzer[2], Betsy Mappilaparampil[2], YAC Youth Action Council members[2]

[1]University of Michigan, Ann Arbor, Michigan, USA. [2]Impression 5 Science Center, Lansing, Michigan, USA

Abstract

Despite promising meaningful STEM engagement for youth, many informal science institutions still reflect White supremacy and patriarchal worldviews in discourses, structures, and practices. Using a participatory ethnographic approach, we explored how a regional science Centre, located in a mid-western city in the United States, engaged in transformation as they sought, in collaboration with youth and university partners, to "reclaim" the Centre from its colonial, White histories. In a Research+Practice Partnership, educators and researchers formed a racially-diverse Youth Action Council (YAC) to redesign areas and programs in the Centre. Our analysis explores how Centre educators facilitated the transformation toward social justice through a set of guiding lenses, and how these lenses led to new collaborative practices for planning and design. These three lenses – racial representation, performative, and authority – exposed how dominant power structures drove the internal functions of the Centre, and created "pausing spaces" for challenging and transforming those dominant power structures through new, emergent discourse, practices and spatialities. We share an illustrative case, involving the transformation of the Centre's iconic Big Mouth exhibit over the course of 24 months, to highlight how these lenses and pausing spaces worked together to support institutional transformation and its impacts on participating educators and youth. Our discussion focuses on implications for enacting a "pausing for justice framework" – made up of the lenses and spaces for advancing the informal STEM learning field toward justice.

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879 Standing on the Brinks of Endangered Culture - Gaps of Ethno-Classification Between Two Generations of Tao People

Yun-Ping Ge

National Taipei University of Education, Taipei, Taiwan

Abstract

Drawing on the theory from cultural psychology, this study investigated the ethno-classification of two generations in Tao people which live in a small island located in the southeast of Taiwan. We focused on the knowledge of classification because this tribe has alternative ways of classifying fish. A categorization task was modified into two phases in order to understand whether senior Tao categorized living things differed from their young generation. A class of Han teenagers recruited from a big city functioned as culture reference. The results evidenced that there existed discrepancy of classification between Tao seniors and teenagers. The categorization of Tao teenagers is more similar with that of Han teenagers by the attributes of living things. However, Tao senior tended to categorize by the shared habitat of living things which might result from their long engagement with the environment since childhood. The factors of gender and education have been examined but not valid in the influence of categorization. Even the senior with bachelor degree had alternative ways of classification. This confirmed the success of science education on the Tao teenagers on the one hand meanwhile it is obvious that these young generation held a very different world view with their senior people. We rejected the science universal perspective to identify seniors' classification as

unscientific. Instead, in align with the call of defining science in a multi-cultural world, we proposed that the curriculum need to support indigenous students to navigate among multiple epistemologies.

1223 Knowledge About My Social Justice Knowledge - Influential Course Elements for the Metacognitive Development of Engineering Students

Sebastian Schäfer[1], Greses Pérez[2], Swetha Nittala[1], Sheri Sheppard[1]

[1]Stanford University, Stanford, California, USA. [2]Tufts University, Medford, Massachusetts, USA

Abstract

This study examines the role of a course on diversity, equity and culture in engineering on students' self-efficacy about incorporating social aspects into their work and understanding of diversity in engineering contexts. Following a case study approach, we collected data from 74 graduate and undergraduate students who participated in the course at a Californian private university. The results suggest that students reported changes in their self-efficacy to incorporate social dimensions in engineering design within the timeframe of the course. Two decisive course elements were identified by students as most influential in their changes: the speaker series and readings of research papers on incorporating culture and diversity. The findings revealed that (i) the combination of speakers and readings influenced students' increased awareness about social justice in engineering compared to other classroom approaches, such as discussions and the final project, and (ii) students documented a change in their self-efficacy to incorporate social justice knowledge in engineering as well as in their metacognitive awareness of influential course elements. It also suggests that incorporating pedagogical elements such as readings and speakers facilitates a concrete understanding of diversity, equity, and inclusion in engineering. Our work contributes to the growing literature on the role of learning about social justice in engineering courses on students' self-perception and metacognitive knowledge.

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900 What Triggers for Change Across Grade in Students' Subjective Task Values Toward Science Learning?

Takuya Matsuura

Hiroshima University, Higashi-Hiroshima, Hiroshima, Japan

Abstract

How to motivate learners in the context of teaching and learning is an important issue. However, it has been reported that Japanese middle and high school students' motivation for science learning is low compared to other countries. Despite high scores in scientific literacy in PISA, Japanese students are below the OECD average in indicators related to motivation, such as "enjoyment of science" and "instrumental motivation for science learning" (e.g., OECD, 2016). In order to examine the factors that reduce Japanese students' motivation toward science learning, we set three research questions to assess students' motivational change and the

triggers of change within the students' subjective task values (STVs) framework (e.g., Eccles, 2005). The results show that regarding the relative ranking of each STVs, it was found that while the percentage of Interest value being Rank 1 did not show an extreme decline in the 8th grade, there was a tendency for Utility value to move to the top and Cost to the bottom. The trigger for change varies by STVs component and that preparation for the high school entrance exam increases the ranking of the Utility value, teacher decreases the Cost and so on.

Parallel Session - 8.19 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Amanda Peters

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58 A Cognitive and Epistemic Account of the Nature of Engineering

Tamar Ginzburg[1], Miri Barak[1], Sibel Erduran[2]

[1]Technion IIT, Haifa, Israel. [2]University of Oxford, Oxford, United Kingdom

Abstract

Educators and policy makers advocate the need for developing engineering literacy among school students; yet, there is an ongoing debate related to the conceptualization of the 'Nature of Engineering' (NOE) and the heuristics that should be applied . Thus, the goal of this paper is to provide a theoretical ground for a nuanced conceptualization of the NOE while drawing on aspects of nature of science through the application of the Family Resemblance Approach (FRA). We review and discuss current studies on school engineering education and the integration of engineering into the science curriculum. We describe four aspects of engineering fields: Structures, Machines, Materials, and Data, each uniquely characterized by the technology used and the artefact produced. Focusing on the FRA's cognitive-epistemic domain, we describe NOE through four categories: Aims & Values, Engineering Practices, Methods & Methodological Rules, and Engineering Knowledge, which can guide the integration of engineering education in schools.

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294 Exploring the Potential of "Enduring Competencies" for Empowering Learners and Connecting Science Curriculum with Cultural Heritage in New Zealand

Sara Tolbert[1], Bronwen Cowie[2], Rose Hipkins[3], Pauline Waiti[4]

[1]University of Canterbury, Christchurch, New Zealand. [2]University of Waikato, Hamilton, New Zealand. [3]New Zealand Council for Educational Research, Wellington, New Zealand. [4]Ahu Whakamua Limited, Kaitaia, New Zealand

Abstract

Drawing from local and international scholarship and recommendations for curricular reform in science, we articulate a set of four enduring competencies to guide teaching and learning in Aotearoa New Zealand: (1) drawing on different knowledge systems, (2) enacting a range of science inquiry practices, (3) working with the literacy practices, and (4) using science for decision-making and action. Research-informed elaborations of the four enduring competencies are designed to provide more explicit guidance about how to design a science curriculum that aims to foster critical, informed and responsible citizenship. Furthermore, the four enduring competencies were designed with attention to mana ōrite, an Aotearoa New Zealand concept that means parity for mātauranga Māori (Indigenous Māori knowledge) with dominant and/or settler-colonial knowledge systems. In this paper and presentation, we discuss the process through which we developed the four enduring competencies for the national science curriculum and assessment refresh process in Aotearoa New Zealand, and share how they are being used to guide curricular reform.

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324 In What Ways Can Indigenous Knowledge Promote a Culturally Responsive Science Curriculum?

Mohd Syafiq Aiman Mat Noor[1,2], Roslinawati Roslan[2], Hardimah Mohd Said[2]

[1]University of Leeds, Leeds, West Yorkshire, United Kingdom. [2]Universiti Brunei Darussalam, Bandar Seri Bagawan, Brunei-Muara, Brunei Darussalam

Abstract

A culturally responsive science curriculum that incorporates indigenous knowledge is essential to ensure that the educational experiences of underrepresented communities are relevant, meaningful, and inclusive. With this as a central ethos, the study employed a participatory, research-based approach to curriculum development to develop a culturally responsive science curriculum using the indigenous knowledge of Iban communities in Brunei Darussalam. The study was executed in two primary phases: the identification of indigenous knowledge harnessed within the communities, and the design of a culturally responsive science curriculum that integrates this indigenous knowledge. In phase one, by utilising the funds of knowledge approach, a significant amount of qualitative data were collected to identify indigenous knowledge, and a reflexive thematic analysis was conducted to analyse the data. In phase two, a systems approach to curriculum development was then applied to design the culturally responsive science curriculum using the identified indigenous knowledge. This curriculum development was supported by an educational package that included a comprehensive learning progression tool, a teachers' toolkit, and inquiry-based learning modules. The curriculum was designed not only to be responsive to the culture of the Iban communities but also to tap into their knowledge, which had previously been neglected in the school curriculum. It is hoped that teachers who teach in Iban schools will be able to put this curriculum into practice for the benefit of Iban children. The study also makes a significant contribution to science curriculum development by highlighting that the process of curriculum development

should not overlook indigenous knowledge as an imperative resource.

588 What Is the 'Problem' With STEM Education in an Australian Context? Realisation of Policy Through Arts-Based Research.

Amanda Peters, Peta White, Jo Raphael

Deakin University, Burwood, Victoria, Australia

Abstract

Science, technology, engineering, and mathematics (STEM) education is highlighted as key to ensuring a well-prepared future workforce with government policies framing the education system as pivotal in realisation of the STEM agenda. However, the ongoing challenge of STEM education remains contested as there is no clear vision for STEM or STEM education by policy makers and stakeholders. To understand the complexities of STEM education, in an Australian context, STEM policy was critically analysed using the 'What is the problem represented to be?' (WPR) approach (Bacchi, 2009). The WPR approach provided a post-structural analytic tool to disrupt normalising discourses in policy rhetoric and probe unexamined assumptions, to interrupt the presumption of STEM policy providing solutions to STEM education. Moving beyond policy analysis, the research intended to investigate the realisation of STEM policy in the secondary school context. A diverse range of STEM education stakeholders' experiences were explored through arts-based approaches including drama-like activities, informed by the findings of the policy analysis. Arts-based research (ABR) complements the WPR approach as it provides a dynamic space to further disrupt and explore policy discourse and assumptions with a focus on problem questioning rather than problem solving. To date, the systematic use of the WPR approach together with ABR, have not been considered. This presentation will outline the findings of analysing STEM policy using the WPR approach, complemented by innovative ABR approaches to realise policy in practice and deepen understanding of the complexities of STEM education to inform future STEM policy and STEM educational reform.

Parallel Session - 8.20 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Kevin Schmitt

89 What are the Effects of Formative Assessment on Students' Science Learning Motivational Beliefs and Behaviors? Comparison between Western and East Asian Learners

Ying Zhan, Zhi Hong Wan

The Education University of Hong Kong, Hong Kong, China

Abstract

Formative assessment has been long emphasised as a powerful means for enhancing science learning. However, there is still a lack of research to investigate the impacts of formative assessment on both students' motivational beliefs and behaviors in science learning. This study examined such impacts using data from six Western and six East Asian countries/ economies in the Program for International Student Assessment (PISA) 2015. 96,491 15-year-old students were included. The analysis of overall data showed that (i) formative assessment had both the direct effects on students' science learning behaviors and the indirect impacts mediated by students' motivational beliefs and (ii) the total effect of teacher feedbacks on science learning behaviors were greater than adaptive instruction. The comparison between Western and East Asian datasets indicated that (i) the impact of teacher feedback on East Asian students' motivational beliefs was greater than their Western counterparts, and (ii) the total effects of teacher feedback on East Asian students' learning behaviors were larger than those of adaptive instruction while the total effects of teacher feedback and adaptive instruction were similar for Western learners. These results revealed the significant roles played by students' motivational beliefs in mediating the relationship between formative assessment and science learning behaviour and cultural difference in students' reactions to formative assessment. Suggestions were made on how to effectively implement formative assessment to enhance science learning in different cultural contexts.

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938 A Diagnostic Toolkit for Secondary Science Teaching

Florian Stern[1], Andreas Müller[2,1]

[1]University of Geneva, University Teacher Training Institute, Geneva, Switzerland. [2]University of Geneva, Faculty of Science, Section of Physics, Geneva, Switzerland

Abstract

Evidence-based practice in science education requires short and validated tests for cognitive, attitudinal and affective factors, that teachers can use to plan, analyze, and improve their teaching. Research has provided a considerable number of tests for such factors, e.g. on conceptual understanding, scientific literacy, interest, self-concept, and others. Our project aims at developing a collection of diagnostic tests for the science classroom for secondary science teaching in [country blinded for review]. The specificity of the project is the close collaboration of teachers and researchers: the former identify classroom variables they find most important, ensure ecological validity for the existing teaching programs, carry out a validation within their own classes, and provide feedback for subsequent improvement; the latter provide research background on existing tests, their theoretical underpinnings, and methodology for test development and validation. We present examples of such a collaborative test development and validation for a course about mechanics. Findings on two levels are reported: on the "product" level, short, ecologically valid tests, showing at the same time satisfactory psychometric indicators. Implications of diagnostic findings for classroom practice are discussed. On the "process" level, a roadmap to achieve this common goal together with

the teacher partners, under the multiple constraints of both practice and research (temporal, curricular, methodological). Potential pitfalls and limitations of the approach will be discussed.

559 Characteristics of Written Examination Questions That Differentiate Between Students Who Have Completed Practical Work in Hands-on and Other Ways in Science Lessons

Alistair Moore[1], Peter Fairhurst[1], Judith Bennett[1], Christine Harrison[2], Catarina Correia[3], Jessie Durk[4]

[1]University of York, York, United Kingdom. [2]King's College London, London, United Kingdom. [3]University College London, London, United Kingdom. [4]Imperial College London, London, United Kingdom

Abstract

Teachers' decisions about the use of laboratory and other practical learning activities in science lessons are influenced by national, high-stakes, summative assessments of the skills and understanding developed through these activities. It is important that such assessments are constructed to reward and incentivise effective practices in practical work in lessons. In England, 16-year-olds' experiences and understanding of practical work in science are now summatively assessed only via written questions in high-stakes national examinations. This quantitative, empirical study investigated whether sets of these written questions with different characteristics could differentiate between students who had experienced practical activities through either hands-on work, teacher demonstration, video demonstration, or reading about the activity. Conclusions are drawn from 1486 post-intervention tests, comprising written questions drawn from national assessments, completed by students aged 14-15 in England. We identify characteristics of written questions that did and did not differentiate between students in the four practical intervention groups, to establish a basis for recommendations to refine such questions in national examinations to better reward and incentivise particular practices in practical work in science lessons.

707 Prior Knowledge in Physics: The Distribution Within Different Subgroups of Students Before Attendings Physics Minors

Kevin Schmitt, Verena Spatz

Technical University of Darmstadt, Darmstadt, Hesse, Germany

Abstract

Against the background of continuously high dropout rates, research on the prior knowledge of students follows a long tradition, especially in mathematics and STEM. So far, however, the focus has mostly been on major students. Therefore, we aim at examining the prior physics knowledge of minor students in selected fundamental content areas (mechanics, electricity, optics). In a preceded pilot study, a test instrument, scaled according to the Rasch model, was developed. With the main study, put forward in this presentation, we now turn to describing

the prior physics knowledge of students in four different non-physics STEM degrees (biology, chemistry mechanical- and electrical-engineering). For this purpose, we have conducted person abilities of the students based on the Item-Response-theory (IRT) and examined the results for significance and calculated descriptive statistics. Our results indicate that the subgroups differ depending on factors which will be discussed. We envision that these results will build a basis for more detailed analyses in the future in order to adjust each physics lecture for minor students addressee-oriented according to their particular weaknesses and strengths.

Parallel Session - 8.21 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Mustafa Sözbilir

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100 The Characteristics and Changes of Preservice Teachers' Teaching Reflection and the Impact on Their Teaching Performance- A Study of a Chemistry Preservice Teacher Training Program

Xijuan Li, Lei Wang

Beijing Normal University, Beijing, Beijing, China

Abstract

Teachers'reflections left preservice teachers aware of areas they should strengthen in their future teaching and reveals their acceptance of teacher educators' guidance (Eric et al., 2014; Amanda et al., 2022). Teaching reflection provides us with an important perspective to understand their pedagogical knowledge and instructional improvement (Nilsson & Loughran, 2012;Tuija A. & Seija, 2012). This study demonstrates the content and characteristics of preservice teachers' teaching reflection and the relationship between preservice teachers' teaching reflection and instructional improvement. Effective strategies for assisting preservice teachers to engage in reflection were elaborated. The study was carried out in a teacher preservice training course during the 2021-2022 school year at Beijing Normal University, China. The 18 preservice teachers participanted in the course.A total of 5 teaching reflections, 5 microlessons, 5 reflective seminars, and 5 mentoring activities concerning teaching practices were selected as the research materials. A collective case study approach (Stake, 1994) and qualitative analysis methods were used. Teaching reflections were coded, clustered and analyzed. A total of 9 contents and 24 subcontents were identified. Each content consisted of 2 to 4 subcontents. Two cases were chosen to analyze the relationship between reflection and instructional improvement during their semester course. Preservice teachers'teaching reflections resulted in improvements in their subsequent instructional design. The results demonstrates that their reflections contributed to instructional improvement. We examined the lecturer's instructional guidance. It was found that the intervention supported teachers' teaching reflection from the following aspects: focusing, comparing, and analyzing the key

points; capturing and questioning the key points; identifying typical problems; and activating deep thinking. Meaningful teaching content and corresponding specific skills were reinforced through preservice teachers'reflections.The guidance provided external evaluation criteria prompted reflection from multiple perspectives and levels. Teacher educators should intentionally lead preservice teachers conduct reflection, explicit reflection, and develop reflecting skills.

460 A Comparative Content Analysis of Chemistry Education Master's Thesis in Finland and Türkiye

Dilek Teke[1], Jarkko Lampiselkä[2], Mustafa Sözbilir[1]

[1]Ataturk University, Erzurum, Turkey. [2]University of Helsinki, Helsinki, Finland

Abstract

The aim of this research is to compare the chemistry education master's thesis published in Finland (FIN) and Türkiye (TR) by the content analysis of the chemistry subject, didactic focus, main aim of the study, research methods, data collection tools, target audiences and data analysis. Data were gathered from total of 90 chemistry education master's theses, 48 from TR and 42 from FIN, between 2015-2019. The results were presented by descriptive statistics in the form of charts, percentages and frequencies in tables. Results indicated that matter and related titles such as physical and chemical states, change of state, particulate nature of the matter in TR and practical works in FIN come to the fore as the chemistry subject of master's theses. In addition, the didactic focus of the thesis is mostly the results of the student's actions, course and causal relations and/or predictions; In FIN theses, the teacher's didactic activities are focused on the course and causal relations and/or predictions. In addition, TR theses are employed more qualitative approach while FIN theses are more focused on mixed approach.

801 The Development and Validation of an Instrument Designed to Measure Content Knowledge for Teaching Organic Chemistry

Bongani Prince Ndlovu, Elizabeth Mavhunga

University of the Witwatersrand, Johannesburg, Gauteng, South Africa

Abstract

The distinction between the subject matter content of the academic discipline and school subjects has not found enough attention in teacher education research, particularly in science education. Existing studies have pointed to the importance of content knowledge in the development of good PCK. However, this postulation does not provide clarity about the version of the content that is referred to. Is it academic discipline or school subject content knowledge? This study argued that another version of content knowledge is suitable for pre-service teacher education training and the base for PCK development. This version of content is described by a theoretical construct called Teacher-related Science Content Knowledge (TerSCK). In the absence of valid and reliable instruments to measure this version of the content, this study used

a case of organic chemistry to design a valid and reliable instrument to measure TerSCK on the topic. A mixed-method research approach was followed in which 35 pre-service teachers were purposively sampled. A reference team of experts in the field was also set up to provide insights into the judgment of items and to ensure the content validity of the instrument. Findings indicated an acceptable range of fit statistics of .5 – 1,5 MNSQ values and -2 – 2 ZSTD values confirming validity, using the Rasch Statical model. Reliability indices were also found to be good at .65 and .93 for person and item respectively. The findings of this study are not generalized and recommendations for further studies in other chemistry topics to examine the validity and reliability of the TerSCK construct are made.

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919 Identifying Pre-Service Chemistry Teachers' Reflective Skills: Reflective Indicators

Destan Tekin, Filiz Kabapınar

Marmara University, İstanbul, Turkey

Abstract

This study aimed to improve pre-service chemistry teachers' reflective skills through practices based on reflective skills and to identify reflective indicators. Qualitative data were collected from a total of 11 pre-service chemistry teachers through a semi-structured interview. Data were analyzed utilizing exploratory mixed-methods. Pre-service teachers' responses to the interviews were coded during and after teaching, and these codes were turned into categories. The categories were defined as reflective indicators. Then the frequencies of the indicators they used in their teaching were identified. Pre-service chemistry teachers are expected to design two digital teaching materials in line with the principles based on the cognitive theory of multimedia and to evaluate themselves and then their peers reflectively using a multimedia rubric. Findings revealed that pre-service chemistry teachers used the indicators of "reflection-on-action" and "coping with action" more frequently. Findings also indicate that "reflection-in-action", "showing evidence" and "inaction-in-action" indicators were used less frequently by pre-service teachers in their teaching.

Parallel Session - 8.22 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Nazli Ruya Taskin Bedizel

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247 Biodiversity and Plant Blindness in Pre-Service Teacher Education

Helena Simões[1], Sílvia Ferreira[1,2]

[1]Instituto Politécnico de Setúbal, Escola Superior de Educação, Setúbal, Portugal. [2]UIDEF, Instituto de Educação, Universidade de Lisboa, Lisboa, Portugal

Abstract

Biodiversity is a multidimensional concept and its approach in schools is essential for a sustainable development. Plants are at the centre of ecosystems' biodiversity, however pre-service teachers tend not to recognise them and understand their importance. They present plant blindness, a concept introduced in the late years of the 20th century. This study is focused on a Portuguese pre-service teacher education in Basic Education and addresses the following problem: To what extent educational strategies that value interaction with plants contribute to the promotion of biodiversity and to prevent plant blindness in pre-service teachers? Twenty-seven undergraduate students of two optional subjects answered a questionnaire before and after the implementation of an educational strategy, including field trips and research activities. In this paper, data from a selection of questions is presented, regarding some dimensions of the concept of biodiversity and plant blindness. The overall results stress the importance of exploring plant rich environments and introducing students to plant biodiversity in their immediate surroundings, but also the resistance of some conceptions to change.

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407 Science Teacher Education Pedagogies for Socio-Environmental Challenges: Utilising "The Theatre of the Oppressed"

Betzabe Torres Olave, Vanessa Kind

University of Leeds, Leeds, United Kingdom

Abstract

The UNESCO International Commission on the Futures of Education report (2021) stated the need to develop pedagogies of cooperation and solidarity at all levels of education, expressing an urgency to return pedagogy to the university. We contribute by bringing the 'theatre of the oppressed' (TOTO) as a potential pedagogy to meet socio-environmental challenges in preservice science teacher (PST) education. The paper offers an overview of TOTO, indicating how it has been used in educating other professionals. TOTO emphasises communication, diversity of views, and ethical debate. This pedagogy potentially helps create safe spaces for discussion of challenging issues by inviting PSTs and teacher educators to explore jointly as different actors bringing disciplinary content knowledge. This theoretical work is the background paper for an empirical project under development between England and Chile exploring local and global environmental challenges.

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945 How Future Early Childhood Education Teachers' Emotions Evolve When Researching Socio-Environmental Issues?

Guerrero Fernández Alicia[1], Rodríguez Pérez Lucía[2], Hamed Al-Lal Soraya[1], Solís Ramírez Emilio[1]

[1]Universidad de Sevilla, Sevilla, Spain. [2]Universidad de Cádiz, Cádiz, Spain

Abstract

The current ecosocial crisis and climate emergency demand an urgently organised, resilient and committed citizenry. To this end, environmental education in and for degrowth is an essential tool capable of making teachers in initial training environmentally literate. The dimensions that make up Environmental Literacy are knowledge and skills, attitudes and emotions and behaviours. In this study we focus on the role of emotions by carrying out an analysis of the answers to a questionnaire on Environmental Literacy given to students of the degree in early childhood education. Using a didactic proposal based on the influence of food on climate change, we research which emotions are mobilised when it comes to understanding the impact of socio-environmental problems and action strategies in response to them. Ultimatelly, we concluded that the role of certain emotions is relevant when it comes to learning about problems, undertaking proposals for change, making decisions and implementing behaviours (individual and collective).

1111 Pre-Service Biology Teacher Prerequisities to Design Formative Assessments in Biology Classroom

Nazli Ruya Taskin Bedizel

Balikesir University, Balikesir, Turkey

Abstract

The present study aimed to examine pre-service teacher prerequisites that need to be in place for designing formative assessments in biology classrooms. The study's findings came from 15 pre-service biology teachers before, during, and after completing an FADC program. According to our findings, pre-service biology teachers' prerequisites differed in every step of the formative assessment design. The study's overall finding indicated that there is a need to include assessment training such as FADC to connect theory and practice as part of the teacher education curriculum.

Parallel Session - 8.23 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Büşra Buluş

1274 Simulating the Vertebrate Heart with Arduino Robotic Models

Melek Altıparmak Karakuş, Ayşe Özel

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Abstract

In this research, pre-service science teachers studied with the guidance of STEM-based module in creating ARDUINO robotic models of vertebrate heart simulating both the anatomy and physiology of the heart in vertebrates (Fish-Frog-Reptile-Bird and Mammal). Within the STEM module, they have given a main task that aims building concrete model of the hearts with cheap & accessible everyday materials. Arduino sensors and circuit elements should be integrated on that concrete models and the model should simulate the working system of the heart in vertebrates. With the sensors and circuit elements connected to the Arduino UNO microcontroller, the models will simulate the contraction and relaxation of the heart, the pumping of the blood from the heart to the body, the movement of the blood in the vessels and how the blood circulation occurs. The robotic models were coded by using mBlock (block-based educational coding platform for young students) in ARDUINO mode. In the study, which is planned to be carried out as a quasi-experimental study, experimental group were formed from 2nd, 3rd and 4th grade pre-service teachers (n=33) in Science Education Department. The data of the research were collected by using the "Achievement tests" and "Resistance behaviour scale for the use of robotic technologies in science classrooms." The aim of the research was; to reveal the effect robotic STEM on teaching biological sciences and resistance behaviour of pre-service science teachers towards robotic technologies. The results showed that the academic success were improved with robotic STEM and the views were aimed at increasing the use of STEM and STEM based robotics integrated with the scientific topics in teacher education programs for the benefit of future generations.

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944 Storylines on 'Science Teacher Talent': Constructing the Majority as 'Wrong'

Jeppe Langkjær, Maria Rejkjær Holmen, Bjørn Friis Johannsen

University College Copenhagen, Copenhagen, Denmark

Abstract

In interviews about 'talent' with educators in a preservice science teacher honors program, storylines emerge that position a vast majority of students who do not choose to apply for this program as 'wrong'. Analysis of parallel, partly incommensurable storylines explored in loosely structured interviews that pilot various theoretical perspectives on 'talent', help explain this unfortunate, possibly unintended positioning of students. The idea that structural problems are solved by locating teacher talent with the individual, appears to result from educators attempting to navigate logics that simultaneously draws on teaching as a social solidarity endeavor and neoliberal ideologies that aim to ensure globalized private corporations a highly educated workforce. This study suggests a danger in allowing corporate interests to dictate preservice teacher curricula.

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816 Evidence-Based Practice of Pre-Service Teachers

Pascal Pollmeier, Christoph Vogelsang, Sabine Fechner

Paderborn University, Paderborn, Germany

Abstract

While evidence-based medicine has a long tradition, evidence-based education has become more popular lately. Evidence-based practice in general means integrating the best available evidence from systematic research and the own professional experience into practice (Davies, 1999; Sackett et al., 1996). Evidence plays an important in current societal debates regarding climate change or covid-19 vaccination. However, why is it, that scientific evidence and public opinion often differ from each other? One reason could be seen in the different ways of understanding of laypersons and scientists (Weber & Stern, 2011) which could be routed back to different epistemological understandings. While epistemological beliefs may be connected to specific disciplines or contexts, there may be differences between pre-service teachers of different disciplines in their competence in evidence-based practice. In connection with an Erasmus+ project on evidence-based practice within teacher education, this study aims to analyse possible differences in the competence in evidence-based practice between different disciplines. Moreover, the influence of a practical phase of pre-service teachers on the competence in evidence-based practice should get investigated. Therefore, pre-service teachers of multiple disciplines (N=411) took part in an online questionnaire regarding their competence, beliefs and practical implementation of evidence-based practice. Within a pre-post-design, the influence of first in-service experiences through a practical semester were investigated. Results show that there are no differences between different disciplines or pre- and post-tests in terms of beliefs and competence in evidence-based practice. Only for the implementation of evidence-based practice, there were differences between primary and secondary school level students.

1104 STEM-Based Handmade Paper Workshop in the Context of Cultural Heritage

Büşra Buluş, Nur Cengiz, Miray Ekemen

Yildiz Technical University, Istanbul, Turkey

Abstract

In this study, a STEM-based handmade paper workshop was designed in the context of cultural heritage and this direction, students' views on the science-culture relationship and the engineering design process were determined. In the designed workshop, a discussion was made about the diversity of pulps used in cultures belonging to different civilizations through argumentation. In this study, which was conducted with 14 high school students, the case study method was used. To collect data semi-structured interview form, observation notes, and for the answers of the students on the worksheets document analysis method were used. At the end of the workshop, it was seen that the students expressed the concepts related to the

engineering design process in a more meaningful and relevant way. They thought that science is universal and related to social-cultural values as well, but they had deeper thoughts about associating science with culture.

Parallel Session - 8.24 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Valeria M. Cabello

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751 The Scientific Computational Thinking Practices of Pre-Service Teachers in a Use-Modify-Create Approach

Niklas Karlsen, Siv Gundrosen Aalbergsjø

Oslo Metropolitan University, Oslo, Norway

Abstract

Computational thinking (CT) is a prominent concept in STEM research related to programming in schools. We investigate the relationship between CT and scientific practices as they are proposed by Weintrop et al. (2016), through the development of a learning sequence for pre-service teachers (PSTs) on the use of programming in science education. The PSTs are presented to simulations of natural-science phenomena coded in Scratch, and are asked to use, modify, and create their own simulations (Lee et al, 2011). We use video and sound recordings of the PSTs creating their own simulations to analyse what scientific CT practices are evident in the data. The results indicate that much of the PSTs work were related to the technicalities of getting the code for the simulations working in Scratch, and not so much on exploring the natural-science content of the model being simulated. We suggest changes to the learning sequence to increase the PSTs focus on the scientific aspects of modelling and simulation by being more explicit about using the computational models for understanding a concept and finding and testing solutions.

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766 Science Teacher Education as Second Order Teaching

Jens Jakob Ellebæk[1,2], Jens Dolin[3], Peer Daugbjerg[4]

[1]University College South Denmark, Haderslev, Haderslev, Denmark. [2]University of Southern Denmark, Odense, Odense, Denmark. [3]University of Copenhagen, Copenhagen, Copenhagen, Denmark. [4]VIA University College, Aarhus, Aarhus, Denmark

Abstract

The present research project has as its core to investigate into and develop a model for Second Order Teaching (SOT) and its relation to bildung and competencies in Danish science teacher education. We first designed a general model for establishing a framework for a specified field

and used this model on the international and Danish understandings of SOT. A map over concepts related to SOT was developed and a definition was proposed, as basis for the development of a model for SOT. This model introduces SOT of first, second and third order, which gives possibilities for adapting the proposed understanding of bildung and competencies to these phases in SOT.

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776 Examining Elementary Preservice Teachers' Approximation of Ambitious Science Teaching

Arzu Tanış Özçelik

Aydın Adnan Menderes Unıversıty, Aydın, Turkey

Abstract

This study investigated elementary preservice teachers' (PTs') approximation of reform-based teaching practice, ambitious science teaching. PTs are supported through practice-based teacher education pedagogies to help them develop teaching practices focusing on attending to student thinking. Through case study research, this study investigated 45 elementary PTs' reflections on their approximations of ambitious science teaching. The context of the study included the second science teaching methods course in the elementary education program at a public university in Turkey. Data sources include lesson plans PTs developed, their videos of microteaching around eliciting students' ideas, and individual reflections PTs wrote about their teaching experience. For data analysis, I read the reflections carefully and did open coding to written statements. Based on the patterns, I categorized their responses and developed themes. Elementary PTs' reflections revealed that PTs differentiated ambitious science teaching from the traditional methods of delivering science concepts, and saw ambitious science teaching as a student-centered pedagogy. In addition to the affordances of ambitious science teaching, PTs reported on the difficulties they encountered in planning and implementing the practice in largely populated classrooms. The difficulties they experienced in the planning were grouped into three categories: finding a phenomenon for their microteaching lesson, creating their gapless explanations for the selected phenomenon, and forming the right questions to ask their peers to elicit their initial ideas.

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862 Self-Assessment of Pre-Service Teacher Explanations: Insights for Teacher Education

Valeria M. Cabello

Pontificia Universidad Católica de Chile, Santiago, Chile. Faculty of Education and Millennium Nucleus for the Study of the Development of Early Math Skills (MEMAT), Santiago, Chile

Abstract

Constructing explanations for the science classroom is a complex teaching practice, especially for pre-service teachers. We explored self-evaluation as a tool for noticing elements of

dialogical teaching as a first phase of a longitudinal study for promoting self-regulation in teacher education. Sixty-three first-year pre-service teachers participated in a videoed classroom simulation and self-evaluation of their explanations, considering weaknesses and strengths. We inquired which learning theory elements, behavioralist, cognitivism, or constructivism best expressed the explanation constructed. The more potent aspects identified were using examples, images and graphs. The weakest were highlighting common misconceptions, contextualizing the teaching, and showing explicitly the relevance of learning the topic to promote understanding. Most participants connected their explanation to cognitive and constructivist learning theories as they attempted to link the concepts with students' prior learning and experiences. This article discusses self-assessment as a tool for promoting formative assessment and "noticing" for insights into teacher education, empowering student teachers as active agents in developing their professionalism from the beginning of their preparation.

Parallel Session - 8.25 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Özge Can Aran

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143 Inquiry-Based Learning Teaching as a Basis for Building Research Projects in Science Education and Human Rights: An Experience From In-Service Teacher Training Course

Daniel Manzoni de Almeida, Patricia Marzin-Janvier

UBO, Brest, Bretagne, France

Abstract

The challenges of the contemporary world require a science teaching engaged in a critical, socially engaged, and human rights linked pedagogy in the classroom. This teaching-learning process involves, first of all, the training of teachers. Thus, themes that involve scientific investigation, critical perspective, and human rights should be made opportune in the professional training processes of teachers. Here, our goal was to show the characterization of a discipline in the Master's program at the UBO, city of Brest, France. The results of our analysis show that the participants engaged, in a collective way, with important human rights themes in the construction of practical research projects using different levels of inquiry-based learning teaching sequences as methodological tools for elementary school students. In conclusion, this experience suggests a proposal for training and accountability of future teachers with science and human rights.

180 The Use of Digital Offers for Continuous Professional Development of German Science Teachers Before and During the COVID-19 Pandemic

Rebecca Tscheslog, Ingo Eilks

Universität Bremen, Bremen, Germany

Abstract

Continuous professional development significantly contributes to the quality of teaching and is usually mandatory for teachers in Germany. In order to make continuous professional development attractive and to adapt its organization to the needs of teachers, regular analyses of further professional development behavior and wishes are required. Digital alternatives can complement face-to-face professional development. During the COVID-19 pandemic, there has been a lot of development in the field of digital media in schools. In this survey, teachers' use of digital media for professional development and whether usage behavior has changed since the beginning of the COVID-19 pandemic is examined.

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277 Examination of High School Physics Teachers' Professional Identity in Turkey

Ozden Sengul

Bogazici University, Istanbul, Turkey

Abstract

This paper presents the findings of a multiple case study to understand and explain the in-service high school teachers' professional identity in Turkey. The participants are three physics teachers (male), who have been working in Istanbul for more than 15 years. One teacher graduated from a university in Istanbul, and two other teachers graduated from a university in the east part of Turkey. Each teacher was interviewed through a semi-structured interview protocol and observed in their classroom settings to take field notes. The transcriptions of interviews and field notes were analyzed through open coding to develop categories and themes. The results indicated that three physics teachers' professional identity was defined based on educational experiences, community interactions, their beliefs about knowledge, science, teaching and learning, as well as their classroom practices. These teachers expected the support from the education community (including the universities and Ministry of Education in the district) for in-service teacher training to teach through alternative approaches besides focusing on the standardized testing.

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541 Supporting Formative Assessment Practice for NGSS Tasks

Özge Can Aran[1,2], Erin Furtak[2], Clarissa Deverel-Rico[2], Keelin O'Connor[2]

[1]Hacettepe University, Ankara, Turkey. [2]University of Colorado Boulder, Boulder, Colorado, USA

Abstract

New science standards that emphasize science-as-practice have reinforced the importance of ongoing professional learning opportunities for teachers, particularly in classroom assessment. In this research, we designed professional learning opportunities for high school science teachers on the basis of previous research studies of routines that support teacher learning about formative assessment in science education. Eight high school science teachers participated in an online synchronous and asynchronous professional learning experience during the 2021-22 academic year. We collected multiple sources of data, including surveys, video uploads of teachers' reflections, and field notes. Our findings revealed that as teachers were able to plan for, enact, and reflect upon their classroom practices, possibilities for formative assessment opened up as they learned new framings, yet still faced difficulties in realizing formative assessment practices.

Parallel Session - 8.26 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Elon Langeheim

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278 A Partecipatory Action Research with Primary School Teachers: Integration of an Imaginative Approach into Science Education Practice

Chiara Puecher

Free University of Bolzano, Bolzano, Italy, Italy

Abstract

The following participatory action research project involves a group of teachers from different schools in a northern Italian province in order to test, experiment and integrate an imaginative approach to science into classroom teaching-learning practice. In addition, the project connects the school not only with the academy but also with the European project: teachers have the opportunity to experience the imaginative course curriculum resources that are currently being developed in the European project "e^4 higher Educational tools for an Embodied & creative Education on Energy" focused on the topic of energy. In the course of the research, teachers share their own science education practices, explore the imaginative approach to science and the resources of the e^4 project, design activities for their classrooms and experiment in the classroom with the activities developed. The participatory action research enables the imaginative approach to science and e^4 resources to be informed by the needs and praxis of teachers and to develop good practices that can be transferred to other contexts.

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333 Emotional Rules and Power Relations in Science Teacher Professional Development Discourse

Karin Sarfati Shaulov, Dana Vedder-Weiss, Rotem Trachtenberg maslaton

Ben Gurion University of the Negev, Beer Sheba, Israel

Abstract

To shed light on the role of emotions in science teacher learning, in this case study, we explore the rules of emotion display in a professional development (PD) setting and the power dynamics involved in shaping them. Employing linguistic ethnographic microanalysis, we analyze 28.75 hours of video/audio-data recorded in one elementary and middle-school science teachers' PD program. The detail analysis of one illuminating event demonstrates how emotional rules were constructed through the ways the facilitators and visiting personnel responded to displays of difficult emotions regarding the PD program and the expectations it sets. The analysis demonstrates how the facilitators mitigated and normalized emotion displays thus constructing emotional rules which legitimized the display of difficult emotions as long as they did not problematize the program design or its facilitation and as long as they were regulated and/or transformed to pleasant emotions that contribute to the overall positive atmosphere of the program and its success. This case-study illustrates how PD discourse emotional rules are constructed and how they restrict the open negotiation of ideas and expectations. It illustrates how power is enforced to produce emotional labor that repress teacher agency and engagement in their own professional learning.

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551 The Role of Co-Teaching in the Development of Science Teachers' STEM Teaching Efficacy Beliefs

Ayşegül Tarkin Çelikkiran[1], Mustafa Tüysüz[1], Esen Kondakçi[2], Deniz Dinç[2]

[1]Van Yuzuncu Yil University, Van, Turkey. [2]Middle East Technical University, Ankara, Turkey

Abstract

The purpose of this study was to examine the role of co-teaching practice in developing in-service science teachers' STEM teaching efficacy beliefs. This study utilized qualitative research methods. Data were collected from four in-service science teachers through semi-structured interviews before and after co-teaching practices. During co-teaching practices, each science teacher worked with a science educator; they designed and implemented a STEM lesson together. Results indicated that co-teaching practices have an impact on developing in-service science teachers' STEM teaching efficacy beliefs. Teachers' self-efficacy developed in identifying a STEM problem, preparing a STEM lesson plan, determining an appropriate teaching and assessment method, and using classroom management strategies. Thus, co-teaching is a promising practice for enhancing teachers' STEM teaching efficacy beliefs.

1081 Learning With Invented Models of Electric Conductors in a Computational Microworld

Elon Langeheim[1], Janan Saba[2], Sharona T. Levy[3]

[1]Ben-Gurion University of the Negev, Beer-sheva, Israel. [2]Technion, Haifa, Israel. [3]University of Haifa, Haifa, Israel

Abstract

How do students "figure out" the behavior of electric current in conductors by constructing models? We describe how 8th grade students build models of electric conductors with a NetLogo-based microworld. We draw on a rich set of data, including screen-captures of their work, interviews and questionnaires, to identify different ways students used the microworld. We find that while for some aspects of the concept of electric current, students who invented their original models, were more attuned to the behavior of the models they created. The results are discussed with respect to the role of expressiveness when constructing models that deviate from the ones intended by teachers and curriculum developers, and the specific ways by which such activities may support or hinder learning.

Parallel Session - 8.27 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Estelle Blanquet

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561 An Innovative Didactic Proposal to Reduce Plant Blindness in Early Childhood Education

Beatriz García Fernández[1,2], Blanca Cherino Huertas[1], Esther Paños[3,2], José Reyes Ruiz-Gallardo[3,2]

[1]University of Castilla-La Mancha, Ciudad Real, Castilla-La Mancha, Spain. [2]Botanic Institute. University of Castilla-La Mancha, Albacete, Castilla-La Mancha, Spain. [3]University of Castilla-La Mancha, Albacete, Castilla-La Mancha, Spain

Abstract

Plants constitute an important content from the early years of school. This kingdom of living beings, as a part of the visible nature, is taught in pre-primary education and throughout compulsory education with different approaches and levels of complexity. However, despite their importance and presence in the education curricula, it is common that early childhood students do not recognize plants as living beings, which is known in the literature as plant blindness. This work presents a teaching innovation proposal designed to reduce plant blindness in early childhood education. It was implemented in a classroom of 3-year-old children where the topic of plants was traditionally approached using the textbook, so it was an

innovative educational action. The effect of the proposal was assessed by applying an instrument before and after the intervention. Results show that the didactic sequence allowed to deepen the knowledge of plants in the short term.

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848 Multilingual Students Creating Meaning in Science Through Identity Texts: a Social Semiotic View

Pauline Book, Cato Tandberg

Inland Norway University of Applied Sciences, Hamar, Inland, Norway

Abstract

The study examines how multilingual students (11-12 years) negotiate meaning through writing, drawing, and dialogues in science. Students utilize emotions, reflections, and experiences from other areas than the school when provided with the opportunity to solve an open-ended task related to key concepts in science. Data consists of texts from three multilingual students and excerpts from co-generative dialogues, collected over a period of five months. The focus students created identity texts connected to an inquiry-based science program, followed by a dialogue with a fellow student and a researcher. The data collection was part of a larger research project in which the students and the class teacher were involved. Expressions of meaning in the students' drawing, writing, and oral explanations were analysed by using a social semiotic framework. The findings illustrate that emotions and everyday experiences play a major role in the pupils' work on transforming science knowledge. Furthermore, the findings indicate that students engage through different approaches to the science topic, and experiences from outside school have the potential to create curiosity and negotiation of identity, language, and subject knowledge. The findings are discussed through a lens of social semiotic theory as well as literature involving identity, agency, and investment. The study reflects upon how these aspects are intertwined with subject-specific knowledge when students negotiate meaning. One implication highlighted is the need for consciousness related to students' different use of semiotic resources when solving a given task. Encouraging multilingual students to use their own resources and providing the opportunity to negotiate meaning about challenging concepts and abstract processes includes a potential for these students to transform their science knowledge.

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974 When Science Meets Language in Primary Education: Supporting Teachers for Linguistic Diversity

Maiza Trigo, Christina Siry

University of Luxembourg, Esch-sur-Alzette, Luxembourg

Abstract

This contribution explores a school-university partnership that has supported in-service primary teachers to engage with science education in ways that are responsive to challenges faced by teachers and students in a European country. The [blinded] Center is the space where

researchers and elementary teachers come together, as a community of practice, to engage in cogenerative dialogue in order to address elementary science professional development in a European country. Using a participatory research process and interpretive analytic lens, data from research conducted within the [blinded] Center's projects (video recordings, researchers' notes and reflection pieces) narrate the story of this school-university partnership, unpacking the multilayered building of communities of practice, possibilities of shifting toward open-ended teaching approaches in line with the competency-based approach supported by the An European country national curriculum, and reflection pieces on the tensions arising from the multilingual changing context. Findings reveal the team's work dynamics to support inquiry-based elementary science education is grounded on a structure of collaboration, built upon a process of reflect-dialogue-act (co-teaching included) and which, as examined, can provide recommendations to support sustainable partnerships based on ongoing open dialogue and trusting relationships.

1087 Speech Distribution During Explicit Scientific Inquiry-Based Sequences in French Kindergartens

Estelle Blanquet[1,2], Eric Picholle[3,4]

[1]LACES, University of Bordeaux, Bordeaux, France. [2]INSPE de l'Academie de Bordeaux, Bordeaux, France. [3]INPHYNI, CNRS, Nice, France. [4]University Cote d'Azur, Nice, France

Abstract

In the context of a French research project on the appropriation of elements of scientificity by Kindergarten teachers and their pupils aged 3 to 6 years, we show the presence of several invariants related to the share of speaking by pupils and their teachers. Video recordings using 360° cameras were collected over four years from schools in urban, rural and priority education zones. The teachers used scientific inquiry-based sequences specifically designed by the researchers to introduce explicit elements of scientificity. Since French kindergarten classes have up to 30 pupils, each teacher repeated several times each of the nine sequences, with groups of 4 to 7 pupils. The collected data thus show the same activities carried out with different groups by the same teacher and by different teachers. The video data were transcribed and analysed using multimodal interaction analysis. This communication is based on a first level analysis based on the number of interventions of the participants during the different sequences (speaking turns). The transcripts reveal several invariants: interactions are mostly mediated by the teacher and spontaneous exchanges between pupils remain limited; most classes include pupils of all ages, it is mostly the oldest pupils who speak the most, and a limited number of children do most of the talking. The transcriptions also reveal an appropriation and a verbalization of all the elements of scientificity by the teachers in all the sequences, although in different proportions.

Parallel Session - 8.28 (Oral Presentations)

16:00 - 17:30 Thursday, 31st August, 2023

Chair: Sezen Apaydın

701 The S'ence of Science Activities in Pre-School Science Education

Morten Rask Petersen, Linda Ahrenkiel, Helle Hovgaard Jørgensen

UCL University College, Odense M, Denmark

Abstract

Pre-school science is often carried out as science instructions. However, science can also be found in play and everyday activities that children do without knowing the science in these activities. This study presents a thematic analysis of different kinds of science activities in pre-school settings. The mapping and analysis reveals three different but intertwined categories of science activities (show, slow, and spontaneous science), but also two non-science activity categories with the potential to become science (skewed and silent science). The five S's are unfolded and discussed against a culture of viewing pre-school science as informed and steered by school science.

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859 Culturally Responsive Early Science Education—Perceptions and Practices of Bedouin Minority Teachers

Ornit Spektor-Levy, Idit Shaul

Bar-Ilan University, Ramat Gan, Israel

Abstract

The focus of this study was on leveraging the relevancy of science education through culturally responsive pedagogy (CRP), starting in early childhood science education in Bedouin minority preschools (children aged 3–5 years) in Israel. The Bedouin society is an Arab disadvantaged subgroup, affected by high levels of poverty and lack of proper infrastructure. The main objective of this study was to reveal what are Bedouin preschool teachers' dispositions and practices regarding culturally responsive early science education? 143 Bedouin preschool teachers (seniority in years M=12.23, SD=7.94) responded to three questionnaires and 17 teachers were interviewed. The Bedouin preschool teachers reported they conduct guided explorative activities with children but develop inquiry skills to a lesser extent. They expressed their intentions to implement CRP in their science education plan, but they lack confidence and proficiency. These results strengthen the need to support Bedouin preschool teachers in integrating tradition and cultural scientific knowledge into their science teaching plan, with the aim of narrowing the gap between Bedouin preschoolers and preschoolers from other sectors in early years and in future school studies. The study may provide useful information for the development of culturally responsive professional development programs that are appropriate

for early childhood Bedouin educators, as well as for other minorities.

1021 AI Literacy and Ethics: an Exploration of Young Children's Understanding

Dagmar Heeg, Lucy Avraamidou

University of Groningen, Groningen, Netherlands

Abstract

Artificial Intelligence (AI) educational applications are rapidly growing and so is their potential impact to improve education. To investigate the potential impact, this study aimed to explore how young children make sense of AI concepts by examining children's understanding of basic AI literacy concepts, after participating in a 6-week long AI curriculum. Using a social constructivist AI literacy approach, we performed a qualitative case study, using a primary school classroom in Western Europe with 18 students. Data were collected through online semi-structured group interviews. The data were thematically analysed, using a combination of deductive and inductive coding approaches. The findings showed that: (a) children's basic understanding of AI is strongly connected to their personal experiences with AI, (b) young children are aware of the most common daily life applications of AI and consciously and actively engage with the applications, and (c) even without any personal experiences with the topic, young children are extremely engaged with the concept of AI bias, a subtheme of AI ethics. Overall, the findings illustrate the importance of taking into account the social contexts in which AI tools are used, as children conceptualize AI using their own experiences. The findings of this study speak to the need to use design frameworks informed by social constructivism while designing AI curricula.

1234 The Future of the Early Years Climate Change Education

Sezen Apaydın

Canakkale Onsekiz Mart Universtity, Canakkale, Turkey

Abstract

This study aims to reveal preschool teacher candidates' preconceptions of climate change and thoughts on how climate change can be handled with early years children. The purpose of the research is exploratory, so the qualitative research method was employed, and the study design was basic qualitative research design. A homogeneous sampling strategy was used when determining the study group, as the goal was to work with preschool teacher candidates volunteering as trainers at the CABACAM, which provides free preschool education to children of economically and socioculturally disadvantaged families. Participants consist of twenty-four teacher candidates continuing their preschool undergraduate education while volunteering at CABACAM. Data were collected through individual interviews with preschool teacher candidates using semi-structured interview forms. The data obtained from the interviews were analyzed using content analysis techniques.

Parallel Session - 9.1 (Posters) ESERA Summer Schools

17:30 - 19:00 Thursday, 31st August, 2023

Chair: Mónica Baptista

104 Teacher Questions for Engaging Students in Scientific Practices

Zhongyan Zhang

University of Leeds, Leeds, United Kingdom

Abstract

The purpose of this study is to find out how teachers use questions in secondary biology classrooms to engage students in scientific practices. The study was conducted in large-class settings, three grades, and four schools in one city in mainland China. Purposes of teacher questions were developed inductively, including purposes related to scientific practices, use of questions to emphasize social responsibility, and use of questions to support understanding big ideas in science. Teacher questions are affected by personal, internal, and external factors. The findings show the reasons why a teacher asks a type of questions or a sequence of questions and what might be driving that. Students' views about different types of teacher questions and what they notice about teacher questioning are discussed.

145 Teachers' Self-regulation Learning and Teaching with Focus on Reflection — a Novel Assessment Tool

Avivit Arvatz[1], Yehudit Judy Dori[1,2]

[1]Technion-Israel Institute of Technology, Haifa, Israel. [2]The Samuel Neaman Institute for National Policy Research, Haifa, Israel

Abstract

Self-regulated learning (SRL) is essential for students and educators in the 21st century. In the present study, the Self-Regulated Learning and Teaching Questionnaire (SRLTQ) was adapted both culturally and professionally to teachers from a questionnaire for various learners in higher education. This study aimed at assessing teachers' self-regulation learning and teaching (SRL&T) via the adaptation, implementation, and validation of a novel assessment tool SRLTQ. We describe the application and validation of the questionnaire for in-service STEM and non-STEM teachers (N = 154) in the context of a professional development course. We used exploratory and confirmatory factor analysis, resulting in a tool with good psychometric properties. SRLTQ's final version contains 31 close-ended items, corresponding to six SRL processes: goal setting, self-efficacy, task strategies, help-seeking, elaboration, and reflection. It also includes one open-ended, reflective question that enables triangulation of the teachers'

reflection skill. SRLTQ can be used for mapping teachers' SRL&T during professional development. Future research should aim at understanding whether PD that explicitly develops the teachers' reflection skill results in a general improvement in SRL&T skills.

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160 Acceptance Surveys on Energy Transfer in Electrical Systems for Upper Secondary School Students

Louisa Winter[1,2], Martin Hopf[1]

[1]University of Vienna, Vienna, Vienna, Austria. [2]University College of Teacher Education, Vienna, Vienna, Austria

Abstract

This study focusses on the development of a new curriculum design on energy transfer in electrical systems for upper secondary school students. As is known from physics education research (PER), many students struggle to develop scientifically correct ideas about the concepts of energy and energy transfer in electrical systems, despite receiving instruction on the subject in school. While there are some teaching concepts around that focus on energy in electrical systems, the topic of energy transfer is often left out or only plays a minor role. Furthermore, existing teaching material is often not suitable for the respective age group. To address this issue, a design-based-research project was initiated, that aims to support upper secondary school students understanding of the topic. The new curriculum design uses a field-approach to explain the process of energy transfer in electrical systems and uses acceptance surveys as a research method. Overall, three rounds of interviews have been conducted with a total of 21 students, and the results were analyzed using a qualitative content analysis method. The findings suggest that the key concepts, that form the interview guide, are well-received by the sample, and that further steps can be taken to develop and test a teaching-learning sequence with appropriate material, utilizing these concepts.

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259 Non-Formal Contexts for Primary Teachers´Pck Using Space and Astronomy

Isabel Borges, Isabel Chagas

Institute of Education, University of Lisbon, Lisbon, Portugal

Abstract

The potential of non-formal science contexts for STEM-oriented (Science, Technology, Engineering, and Mathematics) education has been recognized by numerous studies, which recommend integrated and transdisciplinary approaches from an early age in children. However, many teachers do not integrate non-formal teaching into their practices, too many students continue to show insufficient scientific literacy and the literature shows that there is a lack of studies on teacher education programs centered on non-formal contexts. So, this Ph.D. study focuses on two groups of participants, in-service Primary teachers during two editions of a continuous professional development program occurring within a science centre non-formal

context using Astronomy and Space with specially designed educational materials. From a previous longitudinal study along nine-course editions, data revealed the enhancement of teachers' knowledge and improvement of their emotional dispositions. Therefore, the present research aims to clarify and deepen the understanding of the effect of this course, on some aspects of teacher participants' Pedagogical Content Knowledge (PCK). The focused aspects concern the content knowledge, and the pedagogical knowledge. Besides, the research focuses on changes in the dispositions/emotions (interest, enthusiasm, motivation) of participants and also on teachers' difficulties. This is a qualitative study with data collection procedures including participant observation, a two-phase questionnaire, two teachers' (per group) follow-up classroom observations and interviews, and a final form for participants' feedback about the course. Teachers' productions (lesson plans applied to their students, an oral presentation, and an individual reflection essay) are also analyzed according to the course's established criteria. Data analysis is being carried out using content analysis, considering the crossing and internal validation, and using descriptive analysis. Ongoing results revealed the overcoming of misconceptions in teachers, the enhancement in participants' PCK, and notorious improvement in their interest, enthusiasm, and motivation as well as self-confidence.

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491 Citizen Science in Schools: How Does It Contribute to Students' Scientific Competence?

Caterina Solé[1], Digna Couso[1], María Isabel Hernández[2]

[1]Autonomous University of Barcelona, Barcelona, Spain. [2]Education Department, Barcelona, Spain

Abstract

Citizen science initiatives in school contexts have gained popularity in the last years. These initiatives include a great diversity of proposals in terms of the type of the students' contribution to the scientific objectives, the educational objectives aimed, or the resources provided to students and teachers. How these initiatives potentially contribute to students' scientific competence is a topic scarcely researched. In this study of the doctoral thesis we explore, through a systematic review of literature, how are the citizen science initiatives that have been implemented in school contexts and published. The selection of sample have been conducted through the PRISMA protocol, obtaining 103 papers selected. To analyse the citizen science initiatives, a system of coding was created using the constant comparative method that includes the topics discussed before. We have preliminarily defined four types of citizen science initiatives in school context: 1) Students using science; 2) Students helping science; 3) Students learning science collecting data; and 4) Students learning science becoming scientists. These typologies allow us to identify different students' learning opportunities to develop their scientific competence under the term 'citizen science'.

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542 Learning to Evaluate Scientific Evidence in the Age of Digital Information

Daniel Pimentel

Stanford University, Stanford, CA, USA

Abstract

Students frequently turn to the internet for information about scientific and socio-scientific issues. However, they can find it challenging to evaluate the credibility of the information that they find. This study reports on a series of activities designed to teach students to use online reasoning strategies to evaluate science information on the internet and social media. Forty-five ninth grade students in the US participated in 11 activities, embedded in their biology course lessons. Students completed pre and post-tests composed of three constructed response items. Students' scores improved significantly on all three tasks: evaluating source trustworthiness, relevant expertise, and alignment with scientific consensus. Students were more likely to employ strategies to evaluate the credibility of the source of scientific information after participating in the activities. These results suggest that teaching ideas about science along with online reasoning strategies has the potential to help students evaluate scientific information encountered on the internet.

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573 Tracking the Science Identity Development of Youth Educators Through Curriculum Co-Design

Sarah Lee

Vanderbilt University, Nashville, TN, USA

Abstract

This poster explores the development of a youth educator's science identity as she co-design socio-dramatic play activities with a researcher and elementary age students as a sustainability focused summer program. This research is motivated by literature that suggests educators' beliefs about science identity impact their teaching practices and their students' (especially those form minoritized backgrounds) participation in STEM. The[SL1] data for this poster comes from a year-long study that included a 1-hour long pre-interview, eight 10-minute interviews after each co-design session, and another 1-hour long post-interview after 3-days of activity implementation at the summer program. Constant and comparative coding was utilized to show that the youth educator's belief about her science performance, competence, and recognition shifted over the course of the study. Namely, types of "scientific performance" shifted from canonical activities to more everyday practices (e.g., drawing a human body during art class). One constant theme was her desire to change the way she was recognized as a scientist (or not) by others. Her perception of her own competence changed depend on the context in which she imagined herself doing science (e.g., in class vs. in a professional lab vs. in the kitchen). This case study trajectory provide multiple pathways for us to help youth educators perform scientific competence, and encourages researches to continue exploring how we can support students' recognition of themselves as scientists.

774 Supporting Preservice Teachers in Analysing Curriculum Materials: A Design-based Research Project

Markus Obczovsky

Universität Graz, Graz, Austria

Abstract

Science education research aims at improving the quality of teaching and learning science in school. A common approach in science education research to improve this quality is by developing and providing curriculum materials (CM) to support teachers designing instruction in classroom. These CM are often innovative and new for teachers. However, many CM address students rather than teachers and features of the CM that are supportive for student learning are not explicated to teachers. Studies indicate that teachers struggle identify some features in CM that are supportive for student learning or reject some of these features. Therefore, in my PhD project I investigate how to support preservice teachers in science education programs in analysing CM to discover different features of CM, reflect upon their role for student learning and decide whether they are relevant for student learning. For this purpose, our research group iteratively developed a prototypical teaching and learning sequence (TLS) for science teacher education programs in a design-based research (DBR) approach. We implemented two versions of the TLS in a bachelor seminar of our physics teacher education program so far with eight preservice teachers in a first iteration and 13 in a second iteration. In a mixed methods approach, we conducted interviews, used text vignettes with open questions and collected several learning products. The preservice teachers of this study tend to struggle with justifying their decision why features are supportive for student learning and often draw on content knowledge or common sense rather than pedagogical content knowledge. Throughout the TLS a shift of focus in the preservice teachers' argumentation from content of CM to the strategies for teaching or learning the content used in CM can be seen. On a poster I will present the current stage of the DBR project and present the DBR process.

912 Making Use of Analogical Transfer in Context-Based Learning

Lisa Wedekind, Sabine Fechner

Paderborn University, Paderborn, Germany

Abstract

It is often observed that students are unable to transfer the knowledge they have acquired in one context to another. One possible reason for this is the lack of strategies to decontextualise abstract concepts so that students can transfer them to other contexts (Engle, Holyoak & Stigler, 2002). However, the transfer process plays an important role in the learning process as it is essential to solidify knowledge. What is transferred from which source to which target is the focus of the transfer process (Klauer, 1989). This process can be supported by certain strategies (Fogarty, Perkins & Barell., 1992). Analogies have been found to have a positive effect on the

transfer process, as evidenced by the analogical transfer process of Holyoak (2005). Even though there is still a lot of potential overall in research on the transfer process (Gilbert et al., 2011), it is already known that cooperative methods and learning in a social context as well as the learning of metacognitive strategies have a positive influence on the transfer process. On the other hand, memorization should be avoided as it is not conducive to the transfer process (Billing, 2007). In this paper, video data from a previous project (Kehne, 2019) is reanalysed. The intervention phase is analysed in relation to the types of analogies. On the one hand, the aim is to find out whether students can make analogies and what is the best learning environment for this (multiple contexts, invitation to draw similarities etc.). Furthermore, the relationship between the types of analogy and transfer will be taken up by examining what kind of analogy is needed to achieve the highest possible transfer. The study also focuses on the relationship between analogy type and transfer performance.

1251 Educational Escape Rooms: Design, Implementation and Impact Analysis of Immersive, Problem-Solving Learning Experiences in Science Education

Georgios Villias, Mark Winterbottom

University of Cambridge, Cambridge, United Kingdom

Abstract

This study investigates thoroughly the design and practical application of a promising, multi-dimensional educational approach that has emerged recently, namely the Educational Escape Rooms (EERs). Making a reference to their educational potential in terms of facilitating learners to develop 21st century skills, the study attempts to acknowledge which of these 4Cs skills (Critical thinking, Creativity, Collaboration, Communication) are being practiced by students while engaging in an EER activity and whether a measurable development of these skills can be observed. From a practitioners' perspective, the research study seeks answers on how to optimize the design of these didactic interventions in the most efficient, practical and axiological manner. Regarding the study's outcome, the research led to a better understanding of these emerging educational approaches, and specific connections were found between certain puzzle types and the practice of the 4Cs skills.

821 Depicting the Confrontation With Anomalous Data in Models-of-Data

Pascal Pollmeier, Sabine Fechner

Paderborn University, Paderborn, Germany

Abstract

Generating evidence from experiments is an important practice within science and in the science classroom. The process of evaluation of observations and data can be very demanding, especially in the presence of anomalous data. Attempts are made to integrate the data in the existing mental model. Therefore, mental plausibility checks get processed. Within these processes, the data gets compared to the conceptual environment. Besides conceptual

aspects, even meta-conceptual knowledge may be important. Especially epistemological and ontological aspects can have relevant influence on the evaluation of data (Vosniadou, 1994). Existing methods to externalise mental models (e.g. concept maps) mostly focus on conceptual aspects. The method of model-of-data (Chinn & Brewer, 2001) allows to externalise conceptual aspects in context of their epistemological argumentation. While some links may show causal reasoning, others may build up generalisations on basis of specific assumptions and epistemological and ontological beliefs. Within this study, the usage of model-of-data for evaluating anomalous data should get investigated. Therefore, an online (screencasted) interview-study with pre-service primary teachers was conducted. Participants got introduced in the method of model-of-data and were confronted with two experiments, containing anomalous data afterwards. First results show that participants mostly use less complex links (e.g. causal links). Moreover, many links got used inadequately regarding their epistemological and ontological reasoning. Anomalous data was recognised by the participants in different ways. While some participants recognised the intended anomalous data, some did recognise other aspects, which seem to be anomalous to them. The poster will give insights into the main results of the study, as well as the validity of the mental models, externalised through model-of-data.

Parallel Session - 9.2 (Posters) ESERA Summer Schools

17:30 - 19:00 Thursday, 31st August, 2023

Chair: Antonio Quesada

861 Intersections of Femininity, Sexuality, and Mental Health in STEM Trajectories

Nelly Marosi[1,2], Lucy Avraamidou[1], Monica Lopez Lopez[1]

[1]University of Groningen, Groningen, Netherlands. [2]National Kapodistrian University of Athens, Athens, Greece

Abstract

This qualitative single case study explores the participation and underrepresentation of individuals with marginalized identities in STEM through a combined framework of cultural models in STEM and STEM identity. Framed within intersectionality, the study used a life-history approach to trace the course of events of Val, a purposefully selected participant, a queer individual with mental health issues, who is currently doing a PhD in Computer Science, in Northwestern Europe. Data were collected through in-depth, semi-structured interviews and artefacts, such as the River of Life, and were analyzed in three rounds using narrative analysis. The findings of this study include rich detailed data of Val's reflections on their STEM trajectory as for example, the course of their life as they moved towards or away from STEM. We present a short narrative of Val's early undergraduate studies and briefly discuss the cultural norms of

the STEM spaces they encountered, how they positioned themselves in and out of these spaces, the intersection of mental health issues with their physics trajectory, and the intersections of gender and sexuality with the computer science trajectory. Val's story has important implications for individuals with marginalized identities in STEM, especially in relation to the urgency of making space for normalization and representation of femininities and queer identities in STEM and the potential crucial role of more explicit forms of recognition and a non-competitive culture for individuals with mental health issues. The findings of this study a) further confirm the importance of (mis)recognitions in belonginess and identification with STEM and b) contribute to existing knowledge of identity-based research by connecting the cultural norms of a space with STEM identity and the STEM identity with belonginess, (non) engagement, participation, and withdrawing oneself from STEM.

864 Implementing the Science Capital Teaching Approach in a Scientist-Facilitated Intervention

Shannon Stubbs[1], Sarah Carroll[1], Jennifer DeWitt[2], Muriel Grenon[1]

[1]University of Galway, Galway, Ireland. [2]UCL, London, United Kingdom

Abstract

Non-formal science education can give young people the opportunity to learn about science in a way that is more closely related to real world contexts (Bell et al., 2009). Discussion-based, interactive meetings with scientist role models have the potential to positively contribute to young people's perceptions of and interest in science (Woods-Townsend et al., 2015; Yonas et al., 2020). Question and Answer sessions with scientists are a widely run method of short-term, non-formal science engagement with young people. The use of the Science Capital Teaching Approach helps more students relate to science in the formal classroom (Godec et al., 2017). However, little is yet known about the implementation of this approach by scientists, who receive no formal pedagogical training and do not know the children. This project aims to examine the implementation of the Science Capital Teaching Approach in the context of a brief non-formal intervention with scientists.

877 The Influence of the Task Type on Discussion Promoting Cooperative Learning of Physics

Jasmin Kilpeläinen, Terhi Mäntylä, Antti Lehtinen, Pekka Koskinen

University of Jyväskylä, Jyväskylä, Finland

Abstract

The quality of discussion and argumentation affect students' learning outcomes in cooperative learning. To promote discussion, tasks should be open-ended or require interpretation. On the other hand, if tasks are evaluated automatically by a smart learning environment, the solutions must be precise. So, to make cooperative learning in a smart learning environment effective and appropriate, tasks should be both simple enough to be evaluated automatically and open

enough to promote discussion. The aim of this study is to find out how the type of task influences the discussion between students when they are solving physics problems cooperatively in a smart learning environment. Six student pairs from a university-level physics course participated in this study and each pair solved the same six tasks. In addition, all participants in the course were asked to answer a questionnaire related to cognitive load caused by these tasks. The cooperative problem-solving sessions were videotaped and discussions were transcribed. The content of discussions was analysed qualitatively by coding. To explore how students contributed to discussion in every task, task-specific discussion profiles were formed for students based on the content of their speech. The discussion profiles of students who solved the tasks together were compared with each other. According to preliminary findings, in most cases both students participated in the construction of conceptual understanding equally when solving a multiple-choice task. When solving a mathematical or open-ended task, there were more differences in discussion profiles. In these cases, usually one student was presenting more conceptual statements than the other one. At this point of analysis, there seems to be no relation between discussion profiles and cognitive load. Overall, the preliminary results show that the task type might affect the content of the discussion when physics tasks are solved cooperatively in a smart learning environment.

903 Reinforcing the Lone Genius Stereotype? Attitudes and Social Norms in Undergraduate Physics

Amy Smith

Imperial College London, London, United Kingdom

Abstract

This study is part of ongoing PhD research investigating student attitudes and perceptions of social norms for undergraduate physics students, and their influence on behaviour at a UK university. I use a mixed methods longitudinal approach to investigate changes in these attitudes and norms during a student's undergraduate degree; this poster discusses an overview of the findings from two sets of focus groups and three sets of questionnaires conducted over the first two years of an undergraduate physics course. Questionnaires identify student attitudes and comparisons are made to identify any differences (a) for students over time, (b) between staff and students, and (c) between student demographic groups (gender, ethnicity, fee status). Focus group data was analysed using thematic analysis grounded in the theory of planned behaviour. At the beginning of their degree, questionnaires highlighted that both students and staff placed transferrable interpersonal skills such as "cross-cultural awareness" and the "ability to contribute to discussions" as less valuable for a physics student than discipline-based skills such as "problem-solving". Importantly, after one year of instruction students perceived interpersonal transferable skills as significantly less valuable for a physics student than they had at the beginning of their degree. In addition, competitiveness, obsession with the degree and having poor mental health were identified as key themes in the focus groups. Students described neglecting their social lives and a culture of not sharing answers within the department – although there were also efforts to 'fight back' against this. This study

raises questions regarding the effectiveness of current experienced physics curricula in teaching students the importance of cooperation and collaboration and how this may lead to reinforcements of the lonely genius stereotype of physics.

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917 Does Augmented Reality During Chemical Hands-on Experiments Help Students to Connect Representational Levels?

Hendrik Peeters[1], Sebastian Habig[2], Sabine Fechner[1]

[1]Paderborn University, Paderborn, Germany. [2]Friedrich-Alexander-Universität Erlangen-Nürnberg, Nürnberg, Germany

Abstract

Explaining scientific phenomena is main activity in the science classroom. In chemistry, the entities responsible for observable macroscopic changes belong to the submicroscopic level and rest non-visible. Bringing these different levels of representation together often causes problems for many students, so they usually only describe their observations when asked to explain a phenomenon. One reason for these problems might be found in the lack of contiguity that is provoked by strictly separating observation and interpretation in science class. Augmented Reality (AR) technology provides the ability to enhance real environments with virtual models during hands-on experiments and might narrow the gap between macroscopic and submicroscopic level. The presented study examined the influence of using AR during chemical hands-on experiments on the connection of the different representational levels in student-generated explanations. Three comparison groups (AR, animation, and filmstrip) with a total of 104 German secondary school students, conducted and explained two hands-on experiments. The AR group was given access to an AR app displaying virtual models of the processes on the submicroscopic level during the experiments, while the animation and filmstrip groups were provided with the same dynamic or static models after the experiments. In the subsequent explanation phase, the students created explanatory videos by recording their iPad screen. The analysis of the student-generated videos is based on the framework of Andrade et al. (2019) adapted to the specific experiments. Preliminary results show that the AR group included the observations more systematically and more often in their explanations of the second experiment.

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986 Exploring the Transition From Science Teacher Education to the Teaching Profession

Grethe Beiskjaer

University College Copenhagen, Copenhagen, Denmark

Abstract

Bringing new approaches to science teaching such as interdisciplinary, problem-based teaching into schools has proved a slow and difficult process. One of the means to bring about the change has been through teacher education, but it has been contested whether new

teachers were able to transfer what they had learned from education to profession. This study is a qualitative study inspired by constructivist grounded theory which explores how three new teachers educated from programs with an explicit focus on changing science teaching in schools, experience the transition from being a teacher student to being a teacher. The study found that new teachers experienced opportunities to transfer their approaches to science teaching from education to profession in the cases where 1) their teaching profile gave them the flexibility to plan interdisciplinary science teaching, 2) they were supported by management and 3) they experienced support in a community of practice with people they had studied with.

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997 Analogical Reasoning Between Multiple Phenomena to Support Modeling-Based Learning in Primary Education

Julia Elsner, Claudia Tenberge, Sabine Fechner

Paderborn University, Paderborn, Germany

Abstract

National studies show that students benefit from explicitly comparing multiple dissimilar phenomena. In particular, comparison at the structural level is positive for the learning process. Using analogical reasoning, the development of the mental model could be promoted in the sense of conceptual change. Mental models can be used to explain phenomena and play an essential role in modeling-based learning. Modeling-based learning offers the possibility to express the internal mental model in a model (e.g. by drawing) and to explain phenomena with the help of the model. Due to these findings on analogical reasoning, it could be used as a support measure for learning settings such as modeling-based learning. This raises the question of the extent to which analogical reasoning supports modeling-based learning and which concepts can be acquired through such a learning setting. To answer this, an intervention study was planned and conducted in a pre-post design. 63 primary school students took part in the study, equally divided into the intervention and control group. The intervention focuses on learning settings on the topic of solubility of solid substances in water and oil that enable both modeling-based learning and analogical reasoning. The intervention group additionally receives tasks that support analogical reasoning. The acquisition of conceptual knowledge and the effectiveness of the support measure will be assessed with the help of pre-post interviews. The interviews are videotaped and analysed with a video analysis. Preliminary results show that students use analogies to describe the phenomenon. To what extent this is beneficial for the modeling process cannot be determined at this point. The analysis will be completed in summer 2023. The results of the study can be presented at the conference.

1085 Which Teaching Tasks Do Out-of-Field Teachers Feel Least Confident With? Questions, Questions, Questions

Kyla Smith, Judith Hillier, Sibel Erduran

University of Oxford, Oxford, United Kingdom

Abstract

Out-of-field teaching occurs when there is a mismatch between a teacher's specialised knowledge and what they are assigned to teach. This phenomenon is common in many countries and school teaching contexts, and it provides a range of challenges for out-of-field teachers. Biology, chemistry, and physics each have specialised knowledge, terminology, experimental methods, and problem-solving techniques, which may cause teachers to feel out-of-field when teaching in a science specialism other than their own. The Teacher Sense of Efficacy Scale is used to have teachers rate their belief in their capability to execute different teaching tasks. This is used to show which teaching tasks out-of-field teachers are the least confident with compared to their in-field counterparts. The items with the largest difference between in- and out-of-field groups based on effect size relate to the asking and answering of questions.

1131 Engaging Students in Scientific Practices in a Remote Setting

Anna Lager

University of Helsinki, Helsinki, Finland

Abstract

The goal of science education has shifted from students knowing scientific core ideas to developing and using these core ideas and making sense of phenomena through engaging in scientific practices (SPs) (Berland, 2016). The design of the teaching modules should represent real SPs, and support collaboration in order to make science learning engaging and support learning (Andersson, 2007) in different settings. The present study investigated first-year upper secondary students' use of SPs in a remote setting. Students (N = 16) worked in small groups on the assignments that guided students to make sense of phenomena by engaging them in SPs in the context of multiple digital tools and two virtual experiments. Students' actions were recorded with screen-recording software. After the assignments, students participated in the semi-structured interview, which aimed to investigate students' experiences and perceptions. Interview data were analysed by employing thematic analysis. The data revealed that most challenges were related to such SPs as building models, developing scientific explanations, and planning an investigation, though the nature of the challenges was complex. Following the studies on situational engagement (Schneider et al., 2016) the data reveals that the developed assignments supported participants' situational engagement in SPs in a remote setting.

1193 Scientific and Environmental Literacies for Conscientisation: Exploring Opportunities From Science Outdoor Education

Gonzalo Guerrero

Institute of Education, University College London, London, United Kingdom

Abstract

The devastating impacts of climate crisis in Latin America, such as droughts, water scarcity, and glacial retreat – without any mitigation measures – are likely to be complex, given vulnerability criteria se for by the United Nations Framework Convention on Climate Change. Science Education and particularly scientific literacies articulated with environmental literacies have a key role in the promotion of socio-scientific competences towards transformation. Therefore, it is essential to consider new approaches for changing the perspectives and practices of science educators to tackle these challenges. This ongoing doctoral thesis explores opportunities from science outdoor education to raise environmental awareness and foster a critical scientific literacy approach in Chile. In my doctoral project I propose the concept scientific and environmental literacies for conscientisation, based on Paulo Freire's concept 'conscientização'. In this paper, I review and critically analyse the historical and material complexity of the concept scientific literacy. Then, I present two stages of a community-based outdoor project to explore the extent to which outdoor education can enhance the development of pro-ecojustice dispositifs. The research uses qualitative methods to design a collaborative outdoor activity. Using Actor-Network-Theory (ANT), the study frames a socio-environmental conflict as a network of living, non-living, and symbolic elements. This study is based on a collaborative research framework that includes input from 22 interviews and 3 focus groups with pre-service and in-service teachers, scientists, and park rangers from a national park impacted by an environmental conflict in Santiago, Chile. The methodology is framed on Community-Based Participatory Research (CBPR) based on collaborative partnerships between researchers and practitioners contributing to more robust educational theory and practice. The findings suggest that ANT can be a valuable starting point for problematising outdoor activities based on ecojustice towards scientific and environmental conscientisation.

1230 Supporting Primary Education Through Science Teaching for Multilingual Learning Contexts: Research Shifts, Developments and Outcomes Since the Participation on the ESERA Summer School 2021

Maiza Trigo

University of Luxembourg, Esch-sur-Alzette, Luxembourg

Abstract

This contribution aims to present the development of the PhD research since the researcher's participation in the ESERA Summer School 2021, the online Poznan Summer school. The COVID-19 crisis has taken a toll on several levels of the society and, going online on the educational scenario, has put more pressure to the stakeholders involved. Therefore, the focus of the study had to shift from the Portuguese-speaking community in Luxembourg to the country's more general multilingual learning context itself. Meaning that the target participants changed, and, ultimately, not only participants from the professional development offering were included, but the teacher educators themselves and the researchers (all members of the SciTeach Center team) became participants of the research, while discussion the development

of the workshop and its planning. The support from the mentors and group colleagues, experienced during the Summer school, was essential for the new decisions and foreseen outcomes of this research.

Parallel Session - 9.3 (Posters)

17:30 - 19:00 Thursday, 31st August, 2023

Chair: Brett Langenberg

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468 How Primary Students Experience Failures in Engineering Design?: Focusing on Implication for Educational Use of Failures in Science and Engineering Integrated Education

Jisun Park, Juyeon Sim

Ewha Womans University, Seoul, Korea, Republic of

Abstract

This study investigated the causes of failures that primary students faced in the engineering design process and how they coped with them. Data were collected using video- and audio recordings of four lessons of desigining the water collecting device in the unit "Journey of Water". A total of 28 students, who are 4th graders, in four different classes participated in this research. Field notes were made and group interviews were conducted when the unit was over and audio-recorded. What we found in this study is that the causes of failures that students faced were categorized into cognitive factors and environmental factors. Cognitive factors were lack of understanding material properties, scientific inquiry, and scientific concepts. Enviromental factors were lack of time and limited in prepared materials. We could find that most of cognitive factors were controllable factors that students can make improvements. In contrary, environmental factors were out of students' control. We also found that there was only a few cases discussed the cause of failures. Also these small nuber of discussions were led by one or two students in a group. Most of students improvisely attempted improvement without discussion. Furthermore, we could find that some students avoid the failures by loosening thier success criteria or changing test settings. Based on these findings, we suggested educational implication for utilising student failures in engineering design process as constructive failure for their learning.

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159 Scientific Modeling for the Study of the Respiratory System in Early Childhood

S. Lizette Ramos[1], Dulce María González[2], Verónica Pérez Serrano[2]

[1]Universidad de Guadalajara, Guadalajara, Jalisco, Mexico. [2]Instituto Superior de Investigación y Docencia para el Magisterio, Zapopan, Jalisco, Mexico

Abstract

The research analyzes the scientific modeling processes developed by early childhood children when studying the respiratory system model. The sequence of scientific modeling was made up of 13 activities that begin by recovering the children´s ideas of breathing and then develop experiments and tridimensional models where the respiratory system, its components and functions are represented. We propose school scientific modeling as a constant dynamic of creation of theoretical models, which implies the reconstruction of a fact of the world in a scientific fact. Methodologically, our perspective is interpretive. Our data comes from video recordings, drawings, and students´ work. The methods implemented to analyze interaction and images were conversational analysis and compositional interpretation were respectively. Children´s ideas show that while 60% of students associate breathing with the nose, mouth or lungs, 40% associate it with elements such as blood, mind-brain and stomach. They do not identify breathing as a process of exchange but as "something" composed of independent elements (body and air-wind-oxygen). After the modeling activities, students are able to understand the rest of the organs involved in breathing, their name and their functions; they manage to represent them within the silhouette of their body and exemplify the process of exchange. Nonetheless, although some alternative ideas remain, the models built at the end of the sequence were more complete and more complex.

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829 Qualifying Pedagogical Practice in Early Science Education Through a Synthesis of Research Recommendations and Children's Perspectives

Mette Hesselholt Henne Hansen[1], Camilla Bech Blomgreen[2], Dorte Ellinor Christensen Stokholm[3], Mie Christiansen[2], Niels Ejbye-Ernst[3]

[1]VIA University College, Silkeborg, Denmark. [2]VIA University College, Ikast, Denmark. [3]VIA University College, Aarhus, Denmark

Abstract

In a Danish context, no formal education takes place until the age of six. However, since 2018 science has been included as a pedagogical focus area to strengthen informal learning in the age group. We aim to qualify and strengthen pedagogical practice related to early science education (0-6 years) through a combination of three supplementary approaches:

1. We mapped current forms of practice in early science education (0-6 years) in Denmark through a nationwide survey of 1630 institutions in the 0-6 years age range. 765 of these (46%) self-identified as having strong experience with science activities.
2. We performed a review of research published during the last decade to identify approaches to supporting children's recognition of science concepts and perspectives, and to investigate how the attitude, relation, communication and learning management enacted by early childhood professionals contribute to cognition and opportunities for children's participation.
3. Based on our survey data (1), we selected institutions self-identifying as having strong experience working with science. A subset was identified representing three size

classes (small, medium, large) situated in either urban, rural or semi-natural surroundings. We observed science activities at these nine institutions, and subsequently interviewed groups of participating children. This systematic inclusion of children's perspectives sets a novel context in which to discuss the recommendations identified in the literature review (2).

Combining the synthesis of research recommendations, observations of current practice and children's perspectives, we identify key points of awareness for pedagogical practice. Our results highlight how awareness of the sense-making process at the individual level is crucial for children to find science activities meaningful. We point to specific aspect of dialogue, the embedded context (places and artifacts), and the role of self-determination, to qualify approaches to early science that point towards future education and strengthen early science capital.

1238 A Comparative Analysis of Primary Science Textbooks in Japan and England: Focusing on 'STEAM Activities'

Susumu Nozoe

University of Miyazaki, Miyazaki, Japan

Abstract

In European and American countries that promote STEAM education, its learning activities are practiced in various forms according to the conditions of each country's historical background and social situation. In some countries, the STEAM approach is used in primary education and STEAM research takes place in primary schools. Japan is supporting the promotion and enhancement of cross-curricular learning, especially in high schools, to encourage students to apply their subject knowledge to discover and solve real-world problems. To date, no studies have analysed the relationship between and status of Japanese primary science education vis-à-vis STEAM education. Therefore, the objective of this research was to clarify the characteristics of STEAM education in Japanese primary schools. I conducted a comparative analysis of primary school science textbooks from Japan and science textbooks from England that actively incorporate STEAM-inspired tasks. Specifically, I investigated and organized these science textbooks in detail, using quantitative and qualitative approaches to empirically clarify the characteristics of STEAM activities in primary science textbooks in each country. The results revealed that STEAM activities have mainly been adopted in physics fields in Japanese primary science education, but not equally so in all fields. In contrast, England's primary science education evenly adopted STEAM activities in all fields. Moreover, the study also found that STEAM education in primary science in Japan focuses on activities that connect children's senses to the formation of scientific concepts and activities that utilize scientific properties.

1243 Investigation of Secondary School Students' Mental Risk Taking Skills and Attitudes Towards STEM

İclal Alkan, Nejmettin Yıldırım

İnönü University, Malatya, Turkey

Abstract

In this study, it is aimed to determine secondary school students' mental risk taking skill perception levels and their attitudes towards STEM, and to examine them in terms of gender and grade level variables. In addition, the relationship between students' mental risk taking skills and their attitudes towards STEM was also investigated in the study. The research was designed using descriptive and correlational survey models. The participants of the research are 294 secondary school students (154 girls, 140 boys). As a data collection tool; "Mental Risk Taking Scale" developed by Beghetto (2009) and adapted into Turkish by Yaman and Köksal (2014) and the "STEM Attitude Scale" developed by Faber, Unfried, Wiebe, Corn, Townsend, and Collins (2013) and adapted into Turkish by Yıldırım and Selvi (2015), was used. According to the results of the research, no statistically significant difference was observed between male and female students in the mental risk-taking skill perception levels of secondary school students regarding the science course. According to the grade level variable, a statistically significant difference was observed between the 5th grade students and the 7th and 8th grade students, and it was determined that this difference was in favor of the 5th grades. A statistically significant difference was found between female and male students in favor of male students in the students' attitude scores towards STEM. In terms of grade level variable, a statistically significant difference in favor of 5th grade students was observed between 5th grade students and all grade levels (6th, 7th and 8th grades). A highly significant relationship was also found between students' perceptions of mental risk-taking skills regarding the science course and their attitudes towards STEM.

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97 Can You Make It Back to Earth? A Digital Escape Room to Learn About Green Chemistry

Chantal Lathwesen, Ingo Eilks

University Bremen, Bremen, Bremen, Germany

Abstract

In recent years, educational escape rooms have gained popularity in schools due to their great potential for learning and motivation. To escape as fast as possible, learners must solve different puzzles in a collaborative manner. With the help of escape rooms, content knowledge can be learned and deepened in a playful manner, interdisciplinary skills can be promoted and even learning difficulties can be diagnosed. The puzzle structure is reminiscent of problem- or inquiry-based learning. Therefore, educational escape rooms are particularly suitable for science education. This paper presents the digital escape room "Space Mission", in which students must regain control of a spaceship by learning to make chemical processes more

sustainable and safer using green chemistry principles. The principles of green chemistry integrated into the game have links to various topics, such as oxygen transfer reactions, catalysis, or natural and synthetic substances. Various types of puzzles, e.g., pattern recognition, mathematical and logic puzzles, were used with respect to different abilities of the learners.

521 Exploring Middle School Students' Computational Practices in a STEM-Integrated Instruction on Climate Change

Dilara Kara-Zorluoglu, Gaye D. Ceyhan

Bogazici University, Istanbul, Turkey

Abstract

Interdisciplinary problem-solving is becoming a fundamental requirement for all disciplines. Computational thinking (CT) is one of the critical skills used in a technologically advanced and complicated society for not only in education but also in everyday life as a problem-solving technique. This study examined the STEM-integrated teaching approach applied to middle school students through the use of CT practices and tools. The purpose of the study was to investigate which CT practices eighth graders use while learning about climate change with a STEM approach by using a computational tool. Many CT practices naturally involve with data analysis. In this study, Weintrop and colleagues' (2016) CT practices were integrated into STEM lesson plans designed by the STEM integrated teaching framework (Corlu, 2017). The participants of the study were 30 eighth grade students in a public school, who were selected using convenience sampling method. Students' CT practices were qualitatively analyzed from the worksheets using the rubric developed by Peters-Burton et al. (2022). The results of the study showed that students used decomposition and abstraction practices as high-level practices while algorithms and pattern recognition as low-level practices. As for data practices, students were good at collecting, creating, and visualizing data whereas they had difficulty in analyzing and manipulating data. Results revealed that scientific procedures and data analysis can be made more meaningful by integrating CT practices.

780 Math4U Portal - Do Students and Teachers Focus on the Same Parts of the Curriculum?

Petra Vondráková, Petr Beremlijski

VSB - Technical University of Ostrava, Ostrava, Czech Republic

Abstract

In this paper, we address the question of whether there is a link between the topics that students most often practice and the topics that teachers most often include in tests. We evaluate four years of data collected through Google Analytics. We compare students' approaches to particular topics in secondary school mathematics using Student and Student Easy and teachers' approaches using Math4Teacher. These apps are part of the Math4U practice portal. The authors of this study are key members of the international team developing the apps and

the question databases.

1208 The Effectiveness of Integrating Drama Into Science Teaching in Physics Lesson Among 7th Grade Students

Ahmad Basheer, Ahmad Abu-Alhiga, Naji Kortam

The Academic Arab College for Education in Israel- Haifa, Haifa, Israel

Abstract

Educational Researchers are constantly investigating teaching procedures while examining different strategies aimed at raising the academic achievements, and the present study examines the impact of integrating drama into the teaching process on the academic achievements and classroom climate when teaching and learning science. The study has used a quantitative approach and was participated by one-hundred and ninety-six middle school students from eight 7th-grade classes in Israel. The students learned the unit of "Particle Structure and Properties of Matter" for 16 lessons, with the experiment group learning the topic with drama activities integrated into the teaching, while the control group learned the topic in the traditional/frontal approach. Both groups were examined in pre- and post-tests, and in addition responded to a questionnaire examining the classroom climate. The results of the study showed that student achievements in physics in the experiment group increased significantly and the main improvement was evident among the weak and medium students; no difference in achievements or in improvement was found between boys and girls. It was also found that students in the experiment group reported a more positive classroom climate than students in the control group. The conclusions of the present study prove that integrating drama into teaching is an effective strategy for increasing student achievements, especially for weak and medium students, and that improved classroom climate applies to all dimensions. Therefore, it is recommended to incorporate this strategy into the curriculums of the education system.

1180 Techniques Used by Biology Lecturers to Help Students Learn Biology Terminology

Hlologelo Climant Khoza

University of Pretoria, Pretoria, Gauteng, South Africa

Abstract

Terminology is one of the factors that affect teaching and learning in many Biology classrooms. Yet, the terminology cannot be ignored because it is the content knowledge itself and it is used to communicate science. In this study, we are reporting on how lecturers assist their pre-service teachers in learning and understanding biology terminology. Four (4) teacher education lecturers were observed at different intervals teaching different biology topics to their students. Vignettes were generated from the observations and field notes for coding and to bring out insights. Findings show that lecturers use varied techniques to assist the students in learning

the terminology. What was interesting about the techniques used is that they seemed to be aligned to the nature of the term; if the term explains a process, a mechanism, a structure or a phenomenon. An implication of this study is that lecturers need to pay special attention to the nature of the terminology they use in their lectures. This would then influence the techniques that they use when dealing with these terms.

Parallel Session - 9.4 (Posters)

17:30 - 19:00 Thursday, 31st August, 2023

Chair: Tom Bielik

1118 Educational Computational Chemistry in the TPASK Framework: Design Elements of an E-Learning Course

José Hernández Ramos, Lizethly Cáceres-Jensen, Jorge Rodríguez-Becerra

Universidad Metropolitana de Ciencias de la Educación, Santiago, Chile

Abstract

The educational scenario after the COVID-19 confinement presents new challenges for teachers. Technological advances require teachers to be prepared for instruction through technology, and with this, the need for e-learning courses arose to strengthen this knowledge. This study proposes design elements to develop Technological Pedagogical Science Knowledge (TPASK) in post-pandemic Chemistry teachers through an Educational Computational Chemistry e-learning course. From an overview of the literature, relevant findings were raised concerning Instructional Design and its potential technological support. The results show that the ICCEE (Identification, Choosing, Creating, Engagement, Evaluation) model is suitable for incorporating the constructs associated with TPASK. Based on the above, a course design for educational computational chemistry is proposed together with general guidelines that contribute to the continuous training of in-service chemistry teachers.

1113 Elements Constituting and Influencing Chemistry Teachers' Pedagogical Scientific Language Knowledge

Silvija Markic[1], Corinna Mönch[2]

[1]Ludwig Maximilian University of Munich, Munich, Germany. [2]Ludwigsburg University of Education, Ludwigsburg, Germany

Abstract

Chemish – the scientific language of chemistry – is crucial for learning chemistry. To help students acquire the competencies to understand and use Chemish, chemistry teachers need to have a sound knowledge of teaching and learning Chemish: Pedagogical Scientific

Language Knowledge (PSLK). But still, despite the importance of this knowledge, the question remains what exactly it is. Starting from the results of a systematic review of science teachers' PSLK, this study seeks to examine and systematize chemistry teachers' Pedagogical Scientific Language Knowledge. Therefore, semi-structured interviews with 19 German secondary chemistry teachers are conducted. The interviews are analyzed both deductively using the results of the systematic review and inductively using the approach of Grounded Theory. Finally, the elements of PSLK resulting from the systematic review, as they are knowledge of (i) scientific language role models, (ii) the development of the concept before the development of the scientific language, (iii) making scientific terms and language explicit, (iv) providing a discursive classroom, (v) providing multiple resources and representations, (vi) providing scaffolds for scientific language development, (vii) communicating expectations clearly, and (viii) specific methods and tools for teaching and learning the scientific language, could be described in more detail and even new elements, as they are the knowledge of (ix) the motivation when learning scientific language as well as (x) the knowledge of lesson preparation and follow-up, could be identified and described through the interviews. Furthermore, elements influencing the development of and PSLK itself are characterized. Implications to foster Pedagogical Scientific Language Knowledge during teacher preparation will be given.

1051 Data Systematization of an Inquiry Based Science Teaching Program in Early Childhood Education: A Three-Year Longitudinal Study

Mariana Rodríguez[1], Camila Suarez[2], Mario Chiong[1], Hugo Torres-Contreras[1], Bernarda Inhen[1], María Jesús Viviani[1]

[1]University of Chile, Santiago, Chile. [2]University Of Chile, Santiago, Chile

Abstract

This work is a systematization of the data obtained during the execution of an inquiry-based program to teach science in middle and transition levels in Early Childhood Education (ECE), named PIPE. This initiative was focused to ECE Practitioners (ECEP). Results were obtained between 2020 and 2022 through the assessment of participants and the experience of facilitators. The main results show that the co-design of activities, as well as the implementation of an inquiry-based method to develop scientific skills, are well valued by ECEP. Finally, the strengths of the program, opportunities for improvement and some suggestions for implementing similar initiatives in ECE are disclosed.

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759 Science Teachers' Perceptions of Continuous Professional Development in a Studyvisit to Non-Formal Science Laboratory

Reija Pesonen, Maija Aksela, Johannes Pernaa

University of Helsinki, Helsinki, Finland

Abstract

Non-formal learning environments can offer novel opportunities for teachers' continuous professional development. This study examines the opportunities and challenges for it in non-formal student laboratory during study visits. Data was collected with surveys from 40 teachers and with interviews from five teachers visiting a non-formal student laboratory called ChemistryLab Gadolin at Department of Chemistry, University of Helsinki with students, using a combination of questionnaire and thematic interview methods. The responses were analysed using a theory-guided content analysis. The results indicate that teachers' expectations focus on developing content knowledge in chemistry through theory and experimentation outside the school routine and that teachers felt they had learned it during the visit. The view of the Nature of Science was also broadened to include expectations in the university context, where opportunities to interact with researchers and experience authentic laboratory settings are seen as beneficial for enhancing content knowledge, increasing relevance, and ways to motivate teaching. In terms of developing their own teaching, expectations focused on enhancing working methods to support their work at school, which teachers reported having benefited from during the visit. Based on this study, visits to non-formal chemistry learning environments have the potential to both enhance teachers' expertise and integrate continuous professional development into their working time. They can serve as a venue for teachers to familiarize themselves with new non-formal curricula, however given relevant and timely material.

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647 The Influence of Contextual Factors on the Assessment Practices of Secondary Science Teachers

Ren-Cheng Zhang, Hsin-Kai Wu

Graduate Institute of Science Education, National Taiwan Normal University, Taipei, Taiwan

Abstract

This study proposed and examined an integrated framework for understanding the relationships between contextual factors (i.e., macro, meso, and micro factors) and the assessment practices of secondary science teachers (i.e., what to assess and assessment interpretation and action-taking). This study's sample comprised 872 science teachers from 140 secondary schools in northern Taiwan. Structural equation modeling was employed to test the relationships between variables. The results showed that teachers' practices of what to assess were influenced by the meso factor and by their conceptions of teaching and learning (i.e., traditional and constructivist). Their assessment interpretation and action-taking were associated with the meso factor as well as their conceptions of teaching and their assessment purpose. The macro factor regarding the cultural, policy, and national influences did not directly affect teachers' assessment practices. Overall, the meso and micro factors had a greater influence on science teachers' assessment practices than the macro factor.

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238 Teacher Training to Promote Teachers' Professional Knowledge of NOS

Georg Tinner, Dominik Tschirky, Nicolas Robin, Rahel Schmid

St.Gallen University of Teacher Education, St. Gallen, Switzerland

Abstract

The adequate teaching of Nature of Science (NOS) in the classroom poses challenges for teachers: On the one hand, NOS is a complex construct that is difficult to grasp. On the other hand, the teacher must additionally convey this complex construct. Studies show that teachers' professional knowledge of NOS is insufficient. The poster contribution presents a teacher training in Switzerland which takes this deficit into account. It builds the bridge between research practice and theory on the one hand and teaching practice on the other hand, which is often mentioned and demanded by teachers.

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181 Asynchronous Online Professional Development - A Supplement?

Rebecca Tscheslog, Ingo Eilks

Universität Bremen, Bremen, Germany

Abstract

In order to integrate digital media into science lessons in a meaningful way, the qualification of teachers is essential. A format of asynchronous online professional development courses will be presented, which can supplement face-to-face courses. The short professional development courses all deal with the use of various digital technologies in science lessons. The concept is presented using a specific example of further professional development.

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164 Primary School Teachers' Attitudes Towards Science Teaching: The Impact of a Multidimensional Training Programme

Kalliopi Meli[1], Joanna Taouki[2], Dimitris Pantazatos[3]

[1]University of Patras, Patras, Greece. [2]100mentors, Athens, Greece. [3]National Technical University of Athens, Athens, Greece

Abstract

Teachers' attitudes towards science and science teaching predict their classroom practices. In the present research project, we assessed primary public school teachers' attitudes, and we aim to evaluate the effect of a multidimensional training program on these attitudes. This training programme is focused on how teachers can integrate inquiry-based learning and soft skills development of their students while applying asynchronous mentoring practices into their classrooms to support science education. As case studies, we utilised textbook chapters on physics, biology, and astronomy and relevant laboratory equipment. We developed a research instrument in the form of an online questionnaire to assess teachers' attitudes (N=20) towards teaching science and the application of the aforementioned elements before and after the implementation of the training programme (in progress). The pre-test results indicated that teachers' content knowledge, self-efficacy, and enjoyment in science teaching were mediocre.

At the same time, they expressed uncertainty in explaining and applying the concepts of inquiry-based learning, soft skills, and mentoring. The post-test results will be obtained at the end of the current academic year.

1052 Climate Change Teachers' Academy (CLIMADEMY)

Ioannis Metaxas[1], Emily Michailidi[2], Dimitris Stavrou[2], Nikos Kalivitis[1], Maria Kanakidou[1,3], Olivia Levrini[4], Giulia Tasquier[4], Eleonora Barelli[4], Mihalis Vrekousis[3], Laura Riuttanen[5], Jari Lavonen[5], Athina Ginoudi[6], Giorgia Bellentani[7], Thalia Tsaknia[8], Sofoklis Sotiriou[8]

[1]University of Crete, Heraklion, Greece. [2]University of Crete, Rethimno, Greece. [3]University of Bremen, Bremen, Germany. [4]University of Bologna, Bologna, Italy. [5]University of Helsinki, Helsinki, Finland. [6]Regional Directorate of Primary and Secondary Education of Crete, Heraklion, Greece. [7]Fondazione Golinelli, Bologna, Italy. [8]Ellinogermaniki Agogi, Athens, Greece

Abstract

CLIMADEMY Erasmus + project aims at developing and establishing a network and community of practice in order to establish innovative strategies and programs for preparatory and continuous professional development for serving and student teachers on climate change and its impacts. As a teacher academy will provide educational material focused on the drivers causing the human-induced climate perturbations, the impacts of climate change and essential measures for sustainability. This Academy will be the basis for establishing the Teachers' Academy through one common virtual Climate Auditorium and four hubs in separate countries with specific foci driven by regional particularities. During the three years, 200 trainees across Europe will have piloted the activities through online, physical and blended training so they may act as the seed that will lead to the growth of the network and distribute its aims.

1292 Enhancing Parents' Perspectives on Science Concepts via Science Activities Involving the Family

Tuğba Ecevit[1], Kayahan Ince[2]

[1]Duzce University, Düzce, Turkey. [2]Adana Provincial Directorate of National Education, Adana, Turkey

Abstract

The involvement of parents plays an important role in children's interest in science and their understanding of scientific concepts during their primary school years. Family participation in science activities provides an opportunity for parents to learn with their children and enhance their knowledge and experiences in science. Therefore, the primary aim of this study is to develop family-involved science activities based on inquiry learning approach, and the secondary aim is to investigate the impact of these activities on parents' views of science concepts. Initially, ten different activities with parent and student guides were designed on various topics (such as designing the best paper airplane, food chain, solar system, my house,

geometer, designing your own aluminum boat, you are what you eat, designing your own lamp, take a walk, oil chaos) for fourth-grade students. Each weekend, students completed the planned activities at home with their families. A weak experimental design with pretest-posttest was employed to examine the impact of the activities on parents' views of science activities using quantitative research methods. The study group consisted of 30 primary school students and their 60 parents. The "Parents' Views on Science Activities Scale" was used as the data collection tool. Descriptive and inferential statistics were used to analyze the data. The findings of the study suggest that family-involved science activities conducted over a ten-week period contributed to the development of parents' views on science activities, but this change was not statistically significant.

Parallel Session - 9.5 (Posters)

17:30 - 19:00 Thursday, 31st August, 2023

Chair: Laura Zangori

1273 3D Printing ın Science classroom: Biomolecular Design and Modelling of Central Dogma

Melek Altıparmak Karakuş, Nazlı Mert

Mugla Sıtkı Kocman Universty, Mentese-Mugla, Turkey

Abstract

In this research, pre-service science teachers studied with the guidance of STEM-based module integrating 3D design and printing technologies in teaching Central Dogma unit (DNA replication, transcription, translation) in Biology courses. Within the methodology of integrative design-based STEM module, they have given a main task that aims preparing lesson plans in teaching the topics above for their future science classroom. The lesson plans should be integrated with their original 3D designs and printed materials including almost all of the topics and processes in the Central Dogma unit. The access for information and strategies for 3D Design (Tinkercad- virtual 3D software) and the practical principles of 3D printing process (Ultimaker Cura-3D printing software) were all guided in the second part of the STEM module. The first part of the STEM module was focusing on learning the main subjects and the topics of the Central Dogma metabolism including; the structure and the roles of DNA & RNA, types of DNA & RNA, Proteins, Enzymes, The structure and the role of Ribosome in Protein Synthesis. During the 3D engineering design process; the teacher candidates were asked to collaborate with group members in STEM activities to prepare a joint group presentation including printed 3D visual and tactile models of the biomolecules.In this research, STEM education carried out as a quasi-experimental study. The data for the study were collected with the STEM module itself evaluated by 3D project assessment rubric, academic achievement test and a scale for testing the views about using 3D printing technologies. The data were collected totally from 33

pre-service science teachers and the results showed that the academic success were improved with integrative STEM approach. The views were aimed at increasing the use of 3D printers in schools and developing teaching programs for this purpose.

1145 Elementary Preservice Teachers Adapting Discourse Moves in Microteaching

Arzu Tanış Özçelik

Aydın Adnan Menderes University, Aydın, Turkey

Abstract

In science classrooms, it is important to involve students actively in science through discourse. Teachers need to use discourse moves and strategies to make sure to lead classroom discussions more effectively. Through a qualitative case study, this study investigated to what extent PTs attend to discourse moves in their lesson plans, in their instruction, and in their video analysis. The participants included 30 elementary PTs in their third year at a public university. The context of the study was a science teaching methods course in an elementary teacher education program. Collected data sources in this study include lesson plans PTs developed as a group; video recordings of their instruction, and the PTs' responses to a video analysis activity. Most of the PTs did not attend to students' thinking in their lesson plans. A few groups attend to student thinking in their microteaching. In their instruction, most of the groups followed a traditional pattern of IRE conversation, with very little use of discourse moves. In their video analysis, most of the PTs attended to only certain types of talk moves.

1135 E^4: Training Science Teachers on Energy Using Imaginative Forms of Expression

Tiziana Altiero[1], Mauro Amoruso[2], José Cantó Doménech[3], Federico Corni[4], Hans U Fuchs[4], Chiara Giacomin[5], Ilaria Giovannini[1], Barbara Grazzini[5], Jerusalen Jaime Lahoz[6], Grzegorz Karwasz[7], Cliona Murphy[8], Leonardo Piccinetti[2], Chiara Puecher[4], Katarzyna Wyborska[7]

[1]University of Modena and Reggio Emilia, Reggio Emilia, Italy. [2]Sustainabile Innovation Technology Services Ltd, Limerick, Ireland. [3]University of Valencia, Valencia, Spain. [4]Free University of Bozen-Bolzano, Bressanone, Italy. [5]Ineuropa srl, Modena, Italy. [6]Esciencia Eventos Científicos S.L.., Zaragoza, Spain. [7]Nicolaus Coperniucs University, Toruń, Poland. [8]Dublin City University, Dublin, Ireland

Abstract

Given the urgency of environmental and technological change in the face of challenges such as climate change, we need to raise awareness of possible solutions and necessary measures, particularly through education. We feel the urgent need for supporting and reforming teacher education (for teachers of primary school and lower secondary or middle school levels) at academic institutions in matters concerning energy (energy solutions, energy and the environment, energy and society). In particular, we feel the need for strengthening imaginative

understanding of otherwise daunting issues, strengthening the role of women teachers in these matters, and integrating digital tools for these same purposes. We feel the urgent need for academic institutions charged with teacher education to reach out to the wider community and become meaningful partners in a network with companies and institutions working on our energy future (stakeholders). By themselves, academic institutions could not keep pace with the rate of change in our society in the areas of research, the creation and development of talent and raising Europe's competitiveness in a globalised and rapidly changing world. Here, we present the Erasmus project "eˆ4" through which we intend to create (1) innovative materials for teacher education in the field of energy technology and (2) a network of academic institutions and partners in (energy) industry, agriculture, and public institutions dealing practically with these matters (from hereon called stakeholders). The results of this project—both learning materials for university courses and access to materials, knowledge, and opportunities provided by the network—shall be made available on a dedicated web platform.

1103 Teaching Internship Preparation on the Next Level – a Scrum-Based Concept for the Preparatory Seminar

Dirk Brockmann-Behnsen

Leibniz University Hannover, Hannover, Lower Saxony, Germany

Abstract

The Scrum method originally derives from agile software development. It is characterized by a strong encouragement of the employees to work in a self-responsible way. The supervisor acts rather as an advisor than a manager of the work process. He gives the employees a complex task. The employees get together in small groups and then set their own goals for achieving this task within short work cycles. After each work cycle, the results are critically assessed by the whole team and the goals for the next work cycle are adjusted accordingly. This study explains why this iterative and incremental method is also excellently suited for the education sector and how the individual components of this process model can be transferred to university teaching. At Leibniz University Hannover, this was tested as an example in the preparatory seminar for the school internship. In addition to the description of the concrete implementation of the Scrum concept, the first results of a survey are presented, which was intended to examine how well individual components of the Scrum method are perceived by the participants

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969 Exploring the Development of Pre-Service Chemistry Teachers' Pedagogical Content Knowledge During the Brazilian Pedagogical Residency Program

Luciane Goes, Paulo Loureiro, Carmen Fernandez

Institute of Chemistry - University of Sao Paulo, Sao Paulo, SP, Brazil

Abstract

The Pedagogical Residency Program (PRP) is one of the actions that integrates the Brazilian Policy for Teacher Training and aims to contribute to the initial training of undergraduate students. Thus, it is relevant to investigate whether the pedagogical content knowledge (PCK) can be developed during the experience in the Program. The objective is to document and analyze evidence of PCK that can be observed in pre-service Chemistry teachers during their participation in the program. Data were collected through reports, lesson plans, audiovisual records and reflection stimulated through semi-structured interviews. Qualitative thematic analysis based on the five PCK components proposed by Park and Oliver was used for the data analysis. The results show evidence of manifestations of the PCK components, in addition to moments calling attention to the reflection of the participating students. This highlights the importance of the program for future teachers.

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564 Designing Science Teaching Materials With Design Thinking: Enhancing Pre-Service Science Teacher's 21st Century Skills

İlknur Güven, Merve Sak Yalmanoğlu

Marmara University, Istanbul, Turkey

Abstract

Design thinking is an innovative and solution-oriented approach that requires "thinking outside the box", allowing to approach problems with a human-centered thinking method. This study is about the application of a course based on Design Thinking Approach during one semester at a public university in Istanbul, in Science Teaching program with the pre-service science teachers taking the online Material Design in Science Education course in their third year in the spring semester of 2020-2021 education year. In this context, the aim of this study, was to make pre-service science teachers to learn about design thinking and to use it for problem-solving activities and to develop their 21st century skills. They designed and built science teaching materials with design thinking approach. By analyzing the data from the semi-structured forms of pre-service science teachers, the contribution of the application to their 21st century skills was determined. The suggestions were made in accordance with the findings.

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529 How Preservice Science Teachers Make Space for Students Sense-Making through Multimodal Instruction

Mutiara Syifa, Skye O'beollain, Sophia Jeong, Ashlyn Pierson

The Ohio State University, Columbus, Ohio, USA

Abstract

To help students learn, teachers must make space to elicit students' ideas and support their sense-making process. This study investigates what preservice science teachers (PSTs) noticed during video club activities that support their students' science sense-making. This study used

case studies from two PSTs in the secondary science methods course at a Midwestern university. This study highlighted multimodal instruction that provided students with the space to participate and make sense of science. We suggest that engaging PSTs to notice and reflect on their teaching has helped them prepare their future teaching to be more equitable in supporting students' sense-making.

207 Understanding Professional Learning in Higher Engineering Education through Signature Pedagogies

Mijung Kim[1], Janelle McFeetors[1], Kerry Rose[1], Qingna Jin[1,2]

[1]University of Alberta, Edmonton, Alberta, Canada. [2]Cape Breton university, Sydney, Nova Scotia, Canada

Abstract

Increasing numbers of studies in STEM fields indicate there are higher gains in student outcomes in classroom environments that implement evidence-based teaching approaches focused on learners and their learning, when compared to traditional lecture-based classrooms. However, despite the compelling results, studies show that lecture is still the most common instructor behavior in undergraduate education. Professional learning programs have been shown to be crucial in closing this gap and promoting sustained adoption of student-centered teaching approaches in undergraduate education. In order to understand how faculty members in engineering experience the development of their pedagogical understandings and practice, we invited seven engineering professors to participate in a professional learning program, Scholarship of Pedagogy and Application of Research Knowledge in Engineering (SPARK-ENG), designed specifically for engineering education. The participants' interactions during the community of practice and individual and group interviews after completing their modules were recorded, transcribed, and analyzed through a thematic analysis process. The study findings indicated that the participants experienced the complexity of pedagogical understanding and decision-making over knowledge and practice of engineering, and valued community-based interactions that enabled reflection on their teaching. The study points to the need for further research and discussion surrounding professors' perspectives of the nature of engineering knowledge, and pedagogies that might be congruent with these.

866 A study of university students' visualizations of an epidemic – analysis of drawings from biology and non-biology majors.

Eliza Rybska[1], Costas Constantinou[2]

[1]Adam Mickiewicz University, Poznan, Poland. [2]University of Cyprus, Nicosia, Cyprus

Abstract

The purpose of this study was to explore the representational competence of undergraduate university students and probe the ways in which they visualize their own understandings of the epidemic as a phenomenon. The study is part of a wider project that seeks to investigate the

role of drawing as a learning scaffold and also to explore the extent to which students make connections between their course of studies and wider societal priorities and concerns, a declared priority for STEAM education. The main data consisted of student-constructed drawings with captions. The drawings were coded using a series of qualitative criteria, were categorized and also evaluated with respect to accuracy, comprehensiveness, representations of mechanisms and elaboration of implications. Our findings highlight strong influences from background knowledge and popular media representations on all student drawings. Biology majors tended to focus their representations more narrowly on the underlying mechanisms, whereas non-Biology majors were far more likely to explore social and economic implications of an epidemic. The richness of the drawings demonstrates the value of representational activities in advancing learning and communication. The findings also highlight the need for more inter-disciplinary approaches and the potential for more holistic programmes for the preparation of future Biologists.

Parallel Session - 9.6 (Posters)

17:30 - 19:00 Thursday, 31st August, 2023

Chair: Ram Tamir

1179 Systematic Literature Analysis of the Instruments for Assessing the Level of Sustainability Literacy

Rolf Saarna, Anne Laius

University of Tartu, Tartu, Estonia

Abstract

The aim of the study was to survey the instruments used for assessment of sustainability literacy and components of sustainability against the matrix of SD that includes three dimensions – environmental, socio-cultural and economical within three components – fact-based knowledge and skills, process-based knowledge and skills plus values and attitudes. The research question is posed for this study: What are the instruments used for assessing the sustainability literacy and what are the methods of validating them? The results of systematic literacy analysis showed, that most of the instruments consisted of multiple-choice questions and assessed the level of sustainability knowledge in higher education institutes. None of the studies assessed sustainability literacy in the three dimensions – environmental, socio-cultural and economical within three components – fact-based knowledge and skills, process-based knowledge and skills, also values and attitudes. Out of 24 articles reviewed 12 studies tested validity and reliability. The following methods were used for calculating validity and reliability - composite reliability, confirmatory factor analysis, internal consistency, construct validity.

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636 The Trends of Climate Change Research in Primary Curricula: Implications for Science Education

Mohd Syafiq Aiman Mat Noor[1,2], Roslinawati Roslan[2], Marlizayati Johari[2]

[1]University of Leeds, Leeds, West Yorkshire, United Kingdom. [2]Universiti Brunei Darussalam, Bandar Seri Begawan, Brunei-Muara, Brunei Darussalam

Abstract

The integration of climate change education into primary curricula is crucial in addressing climate change as a pressing global issue and equipping the next generation with the necessary scientific knowledge and skills to act against its effects. Despite the growing attention being paid to climate change research in primary education, a comprehensive review of trends in this field has yet to be conducted in the context of primary curricula. Following the guidelines for conducting systematic reviews in educational research, this systematic review analysed 45 studies to identify patterns and trends. Six core trends connected the studies: geography, chronology, age group, methodology, curriculum interventions, and climate change topics covered. The review demonstrated a disparity in research distribution, with most studies conducted in high-income countries and a scarcity in low-income countries, where the effects of climate change are the most severe. The review also showed that the use of creative and arts-based pedagogies has emerged as a popular approach for upper primary children, with a focus on topics such as causes and effects, mitigation and adaptation, and attitudes towards and behaviours to address climate change. The review has important implications for science education, calling for more research using qualitative and participatory approaches in low-income countries, and for the use of creative and arts-based pedagogies in upper primary education to enhance student understanding. Topics related to climate change should also be integrated with local knowledge and connected to the worldwide issue of global warming.

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232 Towards Sustainability in Science Education: Modelling of Systems Thinking in the Work of Chemists in Academia and Industry

Emmi Vuorio[1], Johannes Pernaa[1,2], Maija Aksela[1]

[1]University of Helsinki, Helsinki, Finland. [2]University of Ljubljana, Ljubljana, Slovenia

Abstract

This study aimed to explore in what context and situations related to sustainable chemistry systems thinking is used or needed by chemists in their work and research. Five semi-structured deep interviews were conducted with chemists from academia and industry, and the data was analysed using a combination of grounded theory analysis and case study. The main results showed that all interviewees' work and research were contributing to creating solutions and applications for the circular economy. They all used systems thinking in terms of evaluating

source materials and considering if the process they were working on was sustainable. The discussion and conclusions emphasized the importance of understanding the sustainability aspects of their work and highlighted that chemists' work and research are essential for sustainable solutions and are connected to larger-scale systems in industry, society, and the global community. The study provides valuable insights for the follow-up study of how systems thinking should be included in chemistry education.

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146 The Effect of Environmental Education Course on Pre-Service Science Teachers' Attitudes Toward Sustainable Development

Asli Koculu, Mustafa Sami Topcu, Mustafa Arslan

Yildiz Technical University, Istanbul, Turkey

Abstract

The aim of this research was to examine the effect of environmental education course on pre-service science teachers' attitudes toward sustainable development. In this research, a single group pre- and post-test model was conducted. The sample of study consists of 56 pre-service science teachers (PSTs) enrolled in 'Environmental Education' course. The data were collected with 'Attitudes toward Sustainable Development' scale. In the data analysis, the paired sample t test was used. Results revealed that there was a statistically significant difference among pre- and post-test total and sub-dimension scores of PSTs' attitudes toward sustainable development in favour of the post-test scores. In other words, 'Environmental Education' course is effective for developing PSTs' attitudes toward sustainable development.

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82 The New Walter Culture: Differences Between Future Teachers in Granada and Melilla

Alejandra Ramírez-Segado, María Rodríguez-Serrano, Alicia Benarroch Benarroch

Universidad de Granada, Melilla, Melilla, Spain

Abstract

The New Water Culture (NWC) claims an integrated and sustainable management of water resources, as advocated by the Water Framework Directive of 2000. This paper presents part of the results of a comparative study carried out in the field of teacher training on the NWC. An ad-hoc questionnaire was administered to a total sample of 1387 prospective primary and secondary school teachers who have studied in Granada and Melilla, both Spanish cities with different water conditions. The significant differences obtained between the population samples showed that the students in training in Granada have a more similar knowledge of the NWC. However, both lack the correct training to transmit the appropriate knowledge in an effective way and thus be able to forge new behaviors in future generations in a visible and permanent way.

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77 Relationship Between the Different Levels of External Mediations Reported by the Students and their Conceptions About the Concept of Light

Juliana Anjos, Agostinho Serrano, Maira Giovana de Souza

ULBRA, Canoas, Brazil

Abstract

This study aimed to investigate the relationship between the level of mediation used by high school students and their conceptions about the concept of light. This link is analyzed through the "External Mediation Level Profile", a tool that analyzes the representations used by the students' verbal and gestural languages, decoded after individual interviews, under the perspective of Cognitive Networks Mediation Theory (CNMT). For the CNMT, there are four different levels of external mediation - Psychophysical, Social, Cultural and Hypercultural - that facilitate the development of mental images by students when answering questions about concepts relevant to light. By raising the profile of each student and confronting him with their conceptions of the nature of light, it is possible to understand their relationships. Results indicated that the level of mediation used by students was closely related to their understanding of the concept of light. The study highlights the importance of utilizing various forms of external mediation in the classroom to aid in students' understanding and retention of scientific concepts.

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856 Practice of "Place-Based Crosscutting Concept Teaching" in Rural Primary Schools

Hui—Chuan Chang[1], Pei-Jung Tsai[2]

[1]The Experimental Primary School of National Dong Hwa University, Hualien, Taiwan. [2]National Dong Hwa University, Hualien, Taiwan

Abstract

The 12-Year Basic Education Curriculum Guideline advocates the development and implementation of scientific literacy and crosscutting concepts in the field of natural sciences (National Academy for Educational Research, 2018). The Next Generation Science Standards (NGSS) in the United States have set the basis of crosscutting concepts for interdisciplinary education, using the practical experiences in line with the actual situation in the country to develop place-based courses and to commit in training teachers to narrow the gap in education between urban and rural areas. However, the relevant implementation still needs to be worked out in detail. This study adopted a qualitative approach, where the researchers and the cooperating teachers would develop the curriculum of "Friends with Light" suitable for the fourth graders based on the interdisciplinary concept of "interaction". The course time was 8 weeks, but data collection lasted six months. The results showed that "place-based crosscutting

concept teaching" not only attracted the students' interest but also effectively helped the students to build up their knowledge about light. The hands-on exercises in the curriculum improved the students' ability to safely operate equipment and arouse their curiosity to exploration. It also increased the chance of cooperative learning and classroom interaction among students, given that the courses still demanded them to learn and solve problems independently. This study would focus on the implementation of place-based crosscutting concept teaching for students in rural areas. While this study provided evidence-based suggestions for the scientific learning and learning identity for rural students, it also promoted the development of crosscutting concept teaching and professional development of teachers, by giving concrete examples of success in the implementation of the 12-Year Basic Education Curriculum.

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466 The Context of Science Fiction in the Pre- and In-service Teachers' Science Education Practice

Matej Vošnjak, Iztok Devetak

University of Ljubljana, Faculty of Education, Ljubljana, Slovenia

Abstract

Science courses cover topics that are often challenging for students because some are often abstract and therefore more difficult for students to understand. For this reason, contextual learning serves as a tool to encourage students to have a more positive attitude toward science learning. Science fiction (SF) is a great example of audiovisual media in which a science context can be presented. The purpose of this study is to investigate the opinions of prospective pre-service and in-service science teachers about the use of context, especially science fiction context in their science education practices. Based on a quantitative research approach, 133 pre-service primary or lower secondary school science teachers and 180 in-service lower secondary school science teachers participated in this study. Participating teachers completed an on-line questionnaire regarding their opinions about context in their science education practice. Results indicate that contextualized teaching and learning is popular among pre-service and in-service teachers. The responses indicate that SF context is of great interest to the majority of pre-service teachers, while on the other hand, one-fifth of the in-service teachers have already used SF context in their science teaching practice and have also received positive feedback from students. Both agreed that the SF context can be an effective tool to get students to uncover or describe alternative conceptions of science phenomena.

Parallel Session - 9.7 (Posters)

17:30 - 19:00 Thursday, 31st August, 2023

Chair: Maria Immaculata Maya Febri

1003 Pre-Service Science Teachers' Explanations of Evolution in the Context of COVID-19

Serap Oz Aydin, Nazli Ruya Taskin Bedizel, Melike Aydar

Balikesir University, Balikesir, Turkey

Abstract

It is essential for individuals to understand and be able to explain the COVID-19 pandemic, a global problem they face in daily life. Furthermore, in order to evaluate the scientific data about the SARS-CoV-2 virus and to understand the changes in the structure of the virus, it is necessary to explain it with evolutionary mechanisms. The present study examined pre-service science teachers' explanations of evolution after instruction using the Covid-19 pandemic context. Participants in the study were 48 senior pre-service science teachers enrolled in the online evolution course at a public university in northwest Turkey during the spring semester of the 2021–2022 academic year. An online assignment is used as the data collection tool. The study's findings revealed that participants tended to explain evolution by providing evidence and using evolutionary mechanisms. As a result, the study's findings revealed that most pre-service teachers could evaluate the contrasting ideas that have been put forward with the emergence of the COVID-19 pandemic using their evolutionary knowledge.

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972 Analysis of the Adaptation of an Experiment by Students in the Pandemic Context

Evelin Carolina Sgarbosa, Marcelo Giordan

University of São Paulo, São Paulo, São Paulo, Brazil

Abstract

Due to the COVID-19 pandemic, the experiments in chemistry classes had to be adapted to the necessity of isolation, resulting in the performance of experiments at home. We analyze in the light of the Activity Theory the adaptations of an experiment proposed in a didactic sequence with the theme of contraceptives. Some students found restrictions to perform this experiment in their homes, given the controversy of themes related to sexuality being a forbidden subject in their families. After pondering the risks, these students created new rules and division of tasks, performing the experiment in person and in groups, despite the instructions given by the teacher. This movement denotes interest and engagement in the activity, as well as the organizational autonomy of this group of students.

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691 Scientists and Public Engagement With Climate Change

Athanasia Kokolaki[1], Nathalia Helena Azevedo[2], Eleonora Barelli[3], Chara Bitsaki[1], Lucy Avraamidou[2], Emily Michailidi[1], Lukas Rokos[4], Dimitris Stavrou[1], Giulia Tasquier[3]

[1]University of Crete, Rethimno, Greece. [2]University of Groningen, Groningen, Netherlands. [3]University of Bologna, Bologna, Italy. [4]University of South Bohemia, České Budějovice, Czech Republic

Abstract

This proposal offers a description of an EU-funded project that aims to support scientists in engaging with the public on issues related to climate change. The project is a collaboration between interdisciplinary research groups from five European academic institutions specialized in STEM education and science communication. The project aims at equipping scientists and science communicators with knowledge and skills necessary to engage the public in personally-meaningful concepts related to climate change . In what follows, we present the general rationale, concepts and goals of the project as well as its design principles and deliverables which include: a) a science communication toolkit for scientists, b) professional development training for scientists, c) interactive infographics and posters and d) an e – learning platform with science communication resources focusing on climate change. As such, the project provides a set of readily available materials that have been implemented and tested in various EU contexts and might serve as an example of good practices connected to engaging the public with concepts related to climate change.

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669 How Social/control Beliefs May Associate With Visual Attention to Information About Plastic Reduction and Behavioral Intention

Fang Ying Yang, Ying-Shao Hsu, Jen-Yi Wu

National Taiwan Normal University, Tapiei, Taiwan

Abstract

The study investigated how high school students attended to information about plastic reduction and how their social/control beliefs and behavioral intention may associate with the attention patterns. A total of 112 students participated in developing a survey (BIS) constructed based on the Theory of Planned Behavior to assess beliefs and behavioral intention while 40 of them were invited to take part in the eye tracking experiment. By factor analysis, three factors were abstracted from BIS, including social beliefs, control beliefs and behavioral intention. Attention patterns were revealed by eye movement measures of fixation types. Correlation analysis found associations among social/control beliefs and intention. Meanwhile, social beliefs correlated with attention to science-related information while behavioral intention associated with attention to information about national actions. The effect of control beliefs and attention to action-related information on behavioral intention was proposed.

373 Undergraduate Students' Decision-Making and Web Searches on an Energy Socio-Scientific Issue

Miki Sakamoto, Etsuji Yamaguchi

Kobe University, Kobe, Hyogo, Japan

Abstract

In order to reach an informed decision on socio-scientific issues, information on different positions must be collected and evaluated. Nowadays, people increasingly rely on the World Wide Web to find information they need. This study aims to explore non-science undergraduate students' web search behavior and their post-search decision-making and to examine the effects of brief intervention that encourage the development of solutions for the issue. The participants were forty non-science undergraduate students. They were required to read basic explanations about a socio-scientific issue regarding energy, to conduct web searches, and to construct arguments explaining their decision on the issue. Half of the participants were assigned to the experimental group and watched instructional videos prior to the task. We broke down the students' essays into their argumentative components and scored the quality of students' decisions. Many non-science undergraduate students wrote arguments by quoting online information of some sort. The brief intervention affected students' web search behavior and socio-scientific decision-making, and encouraged them to develop detailed solutions to resolve the conflicts surrounding the issue.

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318 Championing Awareness of the Opioid Epidemic Through a Service-Learning Module for Non-STEM Biology Majors

Samiksha Raut[1], Sarah Adkins-Jablonsky[2], Cinnamin Cross[1], Ryleigh Fleming[1], Marco Esteban[3], Amy Chatham[1]

[1]The University of Alabama at Birmingham, Birmingham, AL, USA. [2]Alabama College of Osteopathic Medicine, Dothan, AL, USA. [3]Dougherty Valley High School, San Ramon, CA, USA

Abstract

Over 50,000 people die annually from opioid overdoses in the United States leading to what has become known as the "Opioid Epidemic". This is of heightened concern in states like Alabama that experience higher rates of overall drug use and overdose deaths. Thus, it is increasingly important for college students in Alabama to learn about how the opioid epidemic is affecting their communities. Previous studies have demonstrated that engaging non-majors in innovative active-learning oriented pedagogies like service-learning can enhance their understanding and awareness about contemporary societal issues. Despite its pedagogical potential, the impact of opioid-related service-learning, particularly for non-majors, continues to remain unexplored. In this study, we describe the implementation of a service-learning module centered on opioid addiction. Students were equipped with the science behind

opioids, Naloxone training, and active discussions with an opioid researcher, physician and former illicit opioid user in a non-majors biology course. Our assessment of the thematic analysis of pre- and post-reflection data from 87 consenting students revealed 10 categories that students reported in the post- but not pre-reflections (gain), pre- and post-reflections (neutral), and pre- but not post-reflections (loss). We found gains in students humanizing addiction and awareness of the cultural context of opioid addiction and losses from students indicating that they had a low level of awareness related to these issues. Eight one-on-one, semi-structured interviews revealed that students were personally impacted by the epidemic and valued its curricular inclusion. Our data supports that service-learning can increase non-majors biology student's awareness and contextual understanding about the opioid epidemic, enabling much-needed advocacy to further enhance its awareness among the public.

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289 Diffusion of STEM "DI-STEM"

Constantina Stefanidou, Ilias Boikos, Artemisia Stoumpa, Kyriakos Kyriakou, Psoma Vasiliki, Ioanna Stavrou, Vasilis Michalopoulos, Anthimos Chalkidis, Achilleas Mandrikas, Aristotelis Gkiolmas, Konstantina Tsalapati, Theopoula Chrysochou, Maria Hatzaki, Constantine Skordoulis

National and Kapodistrian University of Athens, Athens, Greece

Abstract

A National Research Project entitled Diffusion of STEM is presented in this paper, prompted by the fact that STEM education is usually promoted in specific types of schools and not in the majority of the students' population. To this end, four STEM dissemination Hubs were created, one of which is a pre-existing laboratory in the Department of Primary Education in the National and Kapodistrian University of Athens, while the remaining three are located in three different schools: a primary school in a rural area of Greece, a second chance school and an evening high school, the latter two located in Athens. Following brief research on teachers' and students' needs, teaching seminars were designed for teachers and original educational STEM activities were developed for both students and teachers. All activities are based on environmental issues, namely solar energy, weather and climate, air pollution, energy saving through precise control of household appliances, and promotion of sustainability including physical computing. The project is a work in progress and the first results from the evaluation of the STEM educational seminars and activities are expected in early summer.

1297 Promoting Resilience and Employability in University Project: PREVIEW

Mustafa Hilmi Çolakoğlu

Nevşehir, Nevşehir, Nevşehir, Turkey

Abstract

PREVIEW Project aims to promote innovative learning and teaching practices to address the new societal challenges derived from the digital age by supporting the design and the development of more student-center learning outcomes and curricula that reduce the mismatch between skills supply and demand relevant to the new remote work environment. Particular attention will be given to promoting access by under-represented groups. The project has management, quality assurance, communication, and dissemination activities, peer-to-peer activity by the service design methodology, a methodological framework for learning by doing an activity, a methodological framework for Learning by activity, an ICT Infrastructure supporting remote or blended learning activities; organizing and assessment of 80 remote internships; stimulating virtual collaboration and communication among students, university teachers, and company representatives. The key results are:

- The Learning/Teaching Hub, a digital environment supporting the design, management, and assessment of remote internship programs.
- Service Design Living and Collaborating Laboratories,
- Handbook for the use of the PREVIEW HUB
- MoU to transfer PREVIEW Learning/Teaching HUB outside the Consortium
- MOOC

404 THE HISTORY OF CHEMISTRY IN THE INITIAL TRAINING OF CHEMISTRY TEACHERS. AN EXPERIENCE IN CHILE

Mario Quintanilla[1], Merce Izquierdo[2], Nuria Solsona[2], Macarena Soto[1]

[1]Pontificia Universidad Católica de Chile, Santiago, RM, Chile. [2]Universidad Autónoma de Barcelona, Barcelona, Catalunya, Spain

Abstract

We present and discuss the meta-theoretical and methodological guidelines of an innovative experience that introduces the history of science and philosophy of science in chemistry didactics courses in the initial training of secondary school teachers. The aim is to promote and develop a more comprehensive, interesting, and valuable vision of the production of knowledge in this disciplinary field of science, in the face of the current and diverse challenges imposed by a new culture of science teaching. The debate to which the PQF is intended to invite requires a historical-philosophical approach based on a profoundly human vision of the history of science inspired by hypothetical or moderate rationalism with the intention of not limiting itself to a transmission of information but to promote cognitive-linguistic skills (Izquierdo et al., 2016). The activity is carried out in remote format during the first semester of 2020 (24 classes of 120 min. each) due to the pandemic, for which Teaching Reflection Workshops organized in 3 moments are implemented: i) Theoretical-Informative Moment (MT1); ii) Collaborative Task Resolution (MG2) and iii) Process and Task Evaluation (ME3).The results reveal an interesting reflection on how the formative and theoretical orientation of teachers contributes to a more humane view of chemistry, its teaching and learning. Different

criteria emerge to decide and enhance collaborative work, approaching with this methodology the most relevant and valuable aspects about the production of knowledge in the history of science, promoting a theorized and competent reflection, to understand its meaning and value as a strategy and learning tool for school chemistry and is a formative alternative to the traditional professional development of chemistry teachers.

492 Time Spent Out of Doors and Nature Identity

Laura Wheeler[1], Kathy Cabe-Trundle[1], Rita Hagevik[2], Katherine Vela[1], Michelle Parslow[1]

[1]Utah State University, Logan, Utah, USA. [2]University of North Carolina- Pembroke, Pembroke, North Carolina, USA

Abstract

This research examined how parental encouragement to spend free time outdoors and time spent gardening may affect students' connections to nature. We found positive significant correlations between these variables. Increased time spent gardening was associated with greater nature identity, and informal outdoor experiences hold the promise of environmental benefits, including increased connections to nature. Nature opportunities outside of school are not equitable. Thus, we should provide opportunities for students to engage with nature across multiple contexts both in formal and informal settings (school gardens, public parks) to provide equitable access to nature and green spaces. In utilizing an asset mindset, access to and time spent in school and home gardens provides an opportunity to support students' nature identity.

72 Invited Symposium: Honouring Laurence Viennot's Legacy

Chair

Andree Tiberghien

Discussants

Nicolas Decamp, Victor Lopez Simo, Costas Constantinou, Daniele Buongiorno, Danilo Catena, Marisa Michelini, Lorenzo Santi, Ayçin Ünal, Catherine Bruguiere, Jean-Marie Boilevin, Wanda Kaminski, Valerie Munier, Denise Orange Ravachol

Abstract

The aim of this symposium is to pay tribute to Laurence Viennot who was a pioneer of the research in science education in France and internationally. The contributors from France, and from Spain, Italy, and Cyprus will present the main facets of her rich career in science education research. Her French colleagues will trace the evolution of her research activity, which starts with the spontaneous reasonings of students in mechanics and then extends it to other fields of physics, highlighting the common features of these reasonings associated with the "common sense". They will also discuss Laurence Viennot's work on the study and development of critical attitude among physics teachers towards ritual explanations and the importance of her work for teacher training and biology education, in France. These aspects of Laurence's career have

been widely taken up internationally. The Spanish contribution will focus on some of the key ideas developed by Laurence, physics is counterintuitive but not always difficult, physics teaching should be coherent and rigorous, and learning physics requires developing a critical thinking. The Italian group will illustrate how her work has influenced their approach in an example of a formative intervention module about optical spectroscopy. Finally, her contribution to the MUSE project (More Understanding with Simple Experiments) of the European Physical Society will highlight the importance she has given to the formative development of a coherent conceptual framework for understanding scientific knowledge.

Parallel Session - 10.2 (Symposium)

09:00 - 11:00 Friday, 1st September, 2023

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53 SIG-3 INVITED SYMPOSIUM: Showcasing Research in Out-of-School Science Learning by Junior Scholars

Chair

K.C. Busch

Discussant

María Napal

Abstract

In this SIG-3 invited symposium, we will showcase the research of emerging, junior scholars in the field of out-of-school science learning. Research topics range across three focal areas: science museum educators, science learners, and science museum exhibits. First, scholars will present research about museum educators, including their professional knowledge, their self-efficacy, and their perceptions of culturally relevant practices. Second, scholars will present research on the role of emotion on learning and how people can learn collectively through a community-based environmental movement. Third, scholars will present research about the portrayal of science in exhibit spaces and design principles for a climate exhibit. This symposium will comprise researcher presentations and audience questions.

586 Experience and Professional Knowledge of Brazilian Educators in Out-of-School Settings

Natalia Candido Vendrasco

Pontificia Universidad Católica de Chile, Santiago, Chile

Abstract

In this study, we aim to identify the level of knowledge the mediators have in different out-of-school settings of science education in Brazil and how the years of experience impact their perception of their knowledge. The results emerge from a survey administered to 78 mediators of various types of educational spaces (zoos, aquariums, botanical gardens, museums and science centers) in Brazil, Identifying their perception about 4 categories of professional knowledge (content, context, facilitation and about visitors and their learning). Subsequently, these results were related to the years of experience to identify their influence on this perception.

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817 SIG-3 Invited symposium:the Validation of a New Instrument for Assessing Science Museum Educators' Levels of Self-Efficacy

Megan Ennes, Bikram Karmakar

University of Florida, Gainesville, Florida, USA

Abstract

Understanding educators' levels of teaching self-efficacy can help museums create professional learning opportunities tailored to the needs of their staff as well as for researchers to design interventions to address those specific needs. This study surveyed 406 science museum educators from across the United States to explore their levels of teaching self-efficacy for a wide range of tasks related to their job. We also conducted a factor analysis to understand how different tasks related to one another. This presentation will briefly discuss the development of the instrument, its validation, and some of the results of the survey.

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592 Emphasizing "Culture" When Addressing Diversity, Equity, and Inclusion With Science Center Educators

Mwenda Kudumu

North Carolina State University, Raleigh, North Carolina, USA

Abstract

When working to transform informal science education institutions into racially diverse, culturally inclusive, equitable spaces, it is helpful to understand what staff, who interact with the public at these establishments, know about the relevance of culture to the enactment and interpretation of science, as well as to the public engagement and understanding of science. This presentation describes research that dives deep into the worldviews of science center educators in order to characterize the use of culturally relevant education (CRE) to address issues of diversity, equity, and inclusion (DEI) in informal science contexts. Findings from the study suggest that science center educators considered "culture" central to addressing the lack of DEI, yet when asked to describe their own culture, most of the respondents were flummoxed.

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583 Exploring Collective Environmental Learning and Action

Aparajita Rajwade

North Carolina State University, Raleigh, North Carolina, USA

Abstract

In a Western Indian city, a group of citizens have started an environmental movement to protect their local river from an ecologically harmful river-front development project. This study aims to understand what drives these citizens to volunteer their time and expertise. The overarching research question for this study is "What are the drivers of collective environmental action?" The theoretical framework for this research is based on the social learning theory of communities of practice to examine the social learning and interactions that occur among the citizens who are focused on a common enterprise of protecting their river. This study is using a parallel mixed methods design. Semi-structured interviews of key individuals are currently being conducted using snowball sampling. A survey will also be administered online to all members of the movement (approximately 50) to measure pro-environmental behaviors, environment values, beliefs and collective identity. This study can potentially highlight the benefits of well connected citizen groups such as transmission of information and environmental science learning because of the access to diverse types of knowledge and expertise available across different stakeholders.

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612 Emotional Engagement in Science Museums

Neta Shaby

University of Southampton, Southampton, United Kingdom

Abstract

Emotions play an important role in learning, in all contexts of life. There is a growing interest amongst researchers regarding emotions and emotional engagement related to learning. This growing interest is shared by informal environments' practitioners, particularly science museums. In this research we recruited 15 families that visited the Winchester science Center. One member of each family video recorded the visit using a GoPro camera provided by the researchers. Recorded observations were analysed to shed light on the emotional engagement that takes place within family visits to the museum. This research aims to advance knowledge in the under-theorized field of emotional engagement and applying it to produce practical implications for museum educators.

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590 Developing Climate Exhibits for Shared Engagement and Learning: Emergent Design Conjectures for Museums

Lynne Zummo, Lisa Thompson, Casey Clifford, Claire Davis

University of Utah, Salt Lake City, UT, USA

Abstract

Engaging learners around climate change in ways that do not antagonize or dishearten is no simple task–one that museums have just begun to tackle. While many have argued that museums can and should be important sites of climate learning, empirical research is still comparatively nascent. Extant work has tended to focus on museum educators, producing valuable knowledge on how to engage learners in productive conversations. Yet, research on exhibits is still quite emergent, at a time when it is critical to consider what specific exhibit elements lead to desired outcomes and what could inhibit such outcomes. We advance the field by investigating prototypes of an innovative climate change exhibit, planned to open in 2023 at a natural history museum in the US. Analyzing learner engagement with three prototype interactives, we ask: How do design features relate to learners' discourse? We use qualitative discourse analysis to document relationships between features of these innovative exhibit components and learners' discourse. From this work, we propose emergent design conjectures about supporting productive learning about climate change among diverse learners in museum settings.

Parallel Session - 10.3 (Symposium)

09:00 - 11:00 Friday, 1st September, 2023

41 Dialogues on Power, Culture, Hope, and Science Education

Chair

Matthew Weinstein

Discussant

Laura Colucci-Gray

Abstract

This symposium uses critical dialogues as a method for exploring the politics and culture of science education. The panel consists of scholars working to unearth the politics of practice in Canada, Brazil, England, Australia, and the U.S. This group of researchers have met regularly, co-authored chapters, collaborated on research projects, and developed visions of science education in dialogue with each other. In this symposium we reflect back on the processes of international collaboration, its politics, its possibilities, and the way this community provided transformative support. To make material our connections, we are presenting this as four actual

conversations or dialogues organized around themes from our related research project(s) including the nature of capitalism and power in the present moment, how the resulting assemblages impact the nature of and possibility of citizenship, and science education. We also explore how science and science education have been reconfigured by contemporary power and possibility of science education as a locus of student activism through re-envisioning socioscientific issues as Freirian generative themes drawing on actor-network theory. The dialogues use a variety of theoretical frameworks, theoretical and qualitative research methodologies, research questions, and findings. Our frameworks include critical realism, actor-network theory, Foucauldian analysis of dispositifs, cultural studies of science, postcolonial critical analysis, Marxism, critical social theory, and the pragmatics of the political struggles in which participants are engaged. Because this is a performance of our collaborations, these different framings will be put into conversation with each other. The dialogues address common questions of how science education has been a location of oppression and suffering (considering ecological, racial, capitalist, colonial, gender dimensions). More importantly, we explore the question of 'How science and science education can "speak to the state of the world" and support the "well-being" for students and teachers, given power relations and inequality?' From multiple angles, we examine the question of citizenship in the framework of science education for citizenship. To do so we draw on our joint and individual theoretical, historical, ethnographic, and autobiographical scholarships. One theme of our dialogues both supports and problematizes the conference theme (science education and cultural heritage). We explore how neither science education nor cultures can be treated as innocent, ahistorical, or reified entities. Culture lives within systems of capitalist, patriarchal and colonial political-economies. Our dialogues argue that cultural heritage is riven by politics, power difference, commodification, and inequity even as it provides resources for participation and struggle both inside and outside of institutional science (education) practices. In short, our dialogues strive to make science relevant to the life-worlds of students and the knowledges, symbol systems, and practices that define their (well)being. We read this as the essence of the UNESCO and conference call. We examine how teacher educators, teachers, and students can understand the configurations of power, logic, and ideology that shape both culture and possibility. Our focus is on conscientização or conscientization (Freire, 2000), in which teacher educators, teachers, and students are both subject to and capable of transforming power. Finally, our dialogues creatively imagine science educations that address the state of our worlds.

356 The Political, Economic and Sociocultural Structurings of Science Education

Lyn Carter[1], Ralph Levinson[2]

[1]ACU, Melbourne, Victoria, Australia. [2]University College London, London, United Kingdom

Abstract

Taking the form of a dialogue on the political, economic and sociocultural structurings of science and science education over time, we argue that science and technology are insufficient to explain the contemporary world, and indeed, past worlds. Rather, recognition of science and technology as part of an interacting nexus of diverse actants to explain social phenomena is the most productive way of ensuring genuinely democratic and open systems. Broadening contemporary science educationto account for its political, economic and philosophical assumptions is essential if we are to help prepare young people for the challenges of the world in which they live.

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351 Science Education and Citizenship: A Dialogue

Matthew Weinstein[1], Isabel Martins[2]

[1]University of Washington-Tacoma, Tacoma, WA, USA. [2]Universidade Federal do Rio de Janeiro, Centro de Ciências da Saúde,, Rio de Janeiro, Brazil

Abstract

In this dialogue two science education researchers from Brazil and the United States drawing on their work in curriculum theory and qualitative research explore the relationship of science education to evolving concepts of citizenship. The dialogue explores the similarities and differences between the two societies (including inequality, relationships to past slavery, agricultural economics, and positions within colonial systems) and how those similarities and differences impact a vision of science education and the emergence of STEM as an organizing principle in science education. In our dialogue we trace the continuity of STEM to post-Sputnik science education, as a vehicle for national development and defense. In contemplating these differences, we pay specific attention to the role of Uberization and hyper-consumerism characteristic of the Neoliberal era of capitalism, which have had powerful consequences for the sciences and education, and thus science education which stands at their intersection. The dialogue also explores how the new materialism and Indigenous science practices, both of which theorize a nature with agency. This has led to a radically different models of citizenship, ones that promise a centering of relationship, sustainability, repair, and ethics as a new framing for science educators. Through our dialogue we provide classroom and professional science examples that embody the social impacts of the histories and larger social structures that we are addressing, as well as examples that point to new directions.

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638 The Promise and Perils of Critical Science Education: A Dialogue

Ajay Sharma[1], Matthew Weinstein[2]

[1]University of Georgia, Athens, GA, USA. [2]University of Washington, Tacoma, WA, USA

Abstract

This dialogue explores the character and challenges of critical science education. By critical science education we mean an education that engages with power, that aligns with struggles of oppressed and marginalized communities, and wrestles with the ambiguous place of science in nationalist projects as both a challenge to authority and its servant. This is a reflective dialogue with the author of the culminating, summative chapter of the shared volume published by the presenters in this symposium, a symposium reflecting on their mutual impacts and life projects. The dialogue will explore both the process and substance involved in reflecting on other scholar's works, and the art of such reflection as part of crafting critical science educations. The dialogue examines the common threads and distinctions of our volume, the resonances with his own projects, and will highlight both what the imbricated projects represented by this book reveal and what silences or absences need attention in critical science education. While the topics will be wide ranging, the dialogue will include discussion of the marginalization of critical scholars, the impact of neoliberalism on both science and science education, the question of hope, the variety of critical science educations, and, finally, the need to re-reimagine science educations in the face of climate change–that is to be more forward looking, to move beyond merely addressing the current state of the world–and consider and educate for and towards the enormous impacts that climate change will work on individuals, communities, and governmentalities.

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362 Documenting and Teaching Dispositifs Involved in Citizen Environmental Struggles

John Bencze[1], Chantal Pouliot[2]

[1]OISE, University of Toronto, Toronto, ON, Canada. [2]Laval University, Québec City, QC, Canada

Abstract

In this presentation, we highlight a citizen 'dispositif' (network of living, nonliving & symbolic actants functioning as a mechanism) involved in mobilizations for better air quality in a major Canadian city with an ocean port. We particularly emphasize expansion and contraction of this dispositif over the last ten years by focusing on major episodes of mobilization related to the socioscientific issue of air quality. In a second moment, we address teaching of dispositifs, which we believe is necessary to enable young people to better understand that dynamic relationships among actors and actants allow concerted actions. Students' learning about ways in which dispositifs dynamically-change can also lead to a better understanding of socio-political management (municipal, provincial or federal) of environmental injustices. We believe that understanding dispositifs is hopeful, in that it can nurture 'optimistic' conceptions of citizenship.

Parallel Session - 10.4 (Symposium)

09:00 - 11:00 Friday, 1st September, 2023

54 Connecting Disaster and Risk Studies with Science Education Research

Chairs

Wonyong Park, Benedikt Heuckmann

Discussant

Noemi Waight

Abstract

Science education can be critical for reducing disaster risk in several ways. An understanding of science can equip individuals with the knowledge and skills to understand, mitigate and prepare for potential sources of disaster risk. Students can learn about the underlying causes of natural disasters (e.g., earthquakes, hurricanes, and tsunamis) as well as human-made disasters (e.g., transport accidents, nuclear and chemical disasters, and infrastructure collapses) in school science. Science education can also help individuals develop skills to critically assess the reliability of sources of information. These skills are particularly important in the context of disasters, where quick and accurate decisions can be the difference between life and death. The central premise of this symposium is that science education is central to planning our action against disaster risks. Learning about disaster and risk can be crucial to equip students with knowledge and understanding of the nature of disasters and their relation to science and technology. Citizens need to understand not only the various hazards around them but also the social conditions that shape disaster risk and vulnerability (Kelman, 2020). To do this, science educators need to think across the disciplinary boundaries of science, engineering and social sciences to fully capture the complexities of disasters and educate citizens who are prepared for and resilient to future disasters (Park, 2020). In addition, an informed understanding of disasters has been suggested to be vital to achieving disaster justice and resilience through education (Park, 2020; Preston, 2012). Although knowledge of risk and disaster has been highlighted in international science education and disaster risk reduction policies (NGSS Lead States, 2013; OECD, 2019), existing studies in science education have scarcely drawn on theories of risk and disaster (Park, 2020). This symposium aims to bring together science educators from different education systems to explore the potential connections between disaster studies and science education. By sharing and discussing conceptual and empirical studies at the intersection of disaster risk reduction and science education, the aim is to explore the following questions through presentations and discussion:

- What is the role of science education in reducing disaster risk and building the resilience of individuals and societies?
- How can different types of disasters in terms of the triggering hazards (natural, technological, combined) and the speed (sudden-onset, slow-onset) of disaster be taught in science education?

- How are disasters related to key issues within science education, such as the nature of science and technology, socio-scientific issues, and activism?
- How can science educators design effective learning experiences about disasters, particularly in preservice science teacher education?
- What are some ethical issues that can arise from addressing disasters in science education, and how could they be mitigated?

The four presentations represent different education systems (Germany, Korea and Brazil) and different types of disasters (e.g., climate change, pandemic, chemical disaster), and address a range of issues at the intersection of disaster, risk and science education (e.g., risk perception, textbooks, curricula). The symposium will also showcase exemplary practices that were developed in different education systems. These examples will illustrate how efforts to integrate disaster and risk studies with science education can be situated within the unique cultural and sociopolitical contexts. Given the increasing interest in disaster and risk within science education research in the face of global disasters such as COVID-19 and climate change (Heuckmann & Krüger, 2022; Park, 2020; Pietrocola et al., 2021), the symposium will be of interest to international science educators who wish to learn about how disaster and risk frameworks can inform science education at various levels and in a range of contexts.

1055 How Can Science Education and Disaster Risk Reduction Intersect?

Wonyong Park

University of Southampton, Southampton, United Kingdom

Abstract

One of the central questions that the COVID-19 pandemic has posed concerns the relationship of science, technology and society in times of disasters, and particularly how such a relationship should be addressed to young people across different stages of education. In the past two decades, several major disasters in Korea have provoked science educators' awareness of the need to teach about disasters. Globally, humans are under the threat of natural and technological disasters arising from climate change as well as increasing complexities of technological systems. Although an informed understanding of disasters is essential to promoting disaster resilience and social justice through education, systematic efforts to integrate science and humanities in disaster education have been scarce. This presentation makes a case for addressing disasters in the science curriculum. A conceptualisation of disaster education from the perspective of science education will be suggested with application to specific disaster cases such as the humidifier disinfectant disaster in Korea. Based on an analysis of science curricula and standards, and empirical findings from Korean preservice science teachers, I discuss some possibilities and barriers related to incorporating disasters into science education.

545 Risk Perception and Psychological Distance - How Do They Connect in Science Teaching About Climate Change-Related Health Disaster Risks?

Benedikt Heuckmann

University of Münster, Münster, Germany

Abstract

Science education is central to identifying and understanding risks. Teachers hold a special position in this discourse because they bring risk issues into the classroom and can facilitate (disaster) risk literacy. In previous studies, teachers' risk perception, psychological distance, and willingness to teach have so far been considered as interesting variables separately rather than together. The aim of the present study was to investigate teachers' risk perception, psychological distance, and willingness to teach, as well as their relationship in the context of climate change-related health disaster risks (e.g., tick-borne encephalitis, dermatitis caused by oak processionary moths, Zika virus spread by Aedes mosquitoes, and allergic reactions caused by common ragweed). We conducted a cross-sectional study with 137 German pre-service teachers from three different geographical areas in Germany (North, South, and West) using an online questionnaire that consisted of 18 items for each context. For data collection, we sourced items based on previous studies and evaluated their psychometric properties using factor and internal consistency analyses. Seven-point rating scales were used. The results indicate that psychologically close and thus mentally more present topics are associated with higher risk and, correspondingly, a stronger willingness to address them in the classroom. Furthermore, psychological distance was a predictor for willingness to teach in all contexts, whereas risk perception was not. However, psychological distance negatively predicted risk perception showing that psychologically more distal topics are associated with lower perceived risks. The findings are discussed in the light of the potential for teachers' risk perception, psychological distance, and willingness to teach to transform teaching about disaster risks.

1059 The Impacts of Science and Technology in the Production of Contemporary Risks

Maurício Pietrocola[1], Samuel Schnorr[2], Ernani Rodrigues[3]

[1]University of São Paulo, São Paulo, Brazil. [2]University of Brasília, Brasília, Brazil. [3]Federal University of Espírito Santo, Vitória, Brazil

Abstract

Today's society is increasingly characterised by scientific and technological phenomena. Sociological analyses revealed that science and technology, while offering solutions, also contribute to new uncertainties, producing a Risk Society. In this problematic situation, science education has an important role to play since citizen participation in society requires the ability to assess risks and make decisions, especially in scenarios where discourses contesting science gain space. In this project, we aim to address two important problems of science education in a Risk Society: i) Which scientific contents and teaching-learning situations offer means to

develop the ability to perceive, evaluate and make decisions in the face of risks? ii) How can we train teachers who can implement teaching-learning situations that deal with the risk-confidence pair and involve risk situations and their characteristic uncertainties? We understand that science education, by engaging with with risks and uncertainties, can provide a broader teaching oriented to citizenship education and decision-making based on data and evidence when facing societal problems such as climate emergency, Industry 4.0, and pandemics.

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543 Addressing Disasters in Science Education: How Are Disasters Represented in Korean Science Textbooks?

Yeonjoo Ko[1], Hyunok Lee[2], Hyunju Lee[1]

[1]Ewha Womans University, Seoul, Korea, Republic of. [2]Kangwon National University, Chuncheon, Korea, Republic of

Abstract

The number of natural and human-made disasters such as climate change and COVID-19 has increased over the last decades and will become more frequent and severe in many parts of the world. It is time to consider disasters as an important concept to be addressed in science education. In this study, we explore how disasters are presented in Korean science textbooks. The Korean government introduced disasters as a new unit for 8th grade science in the 2015 National Curriculum. We focus on how disasters are described and represented in the five Korean science textbooks. Specifically, we examine how achievement standards in the national curriculum are translated into science textbooks and what aspects of disaster education are incorporated in the textbooks. Findings indicate that Korean science textbooks are heavily concentrated on a number of limited disaster types (e.g., infectious diseases, earthquakes, and meteorological disasters) and student activities are focused on investigating disaster cases and suggesting countermeasures against disasters based on scientific knowledge. Few textbooks included past disaster examples and referred to disaster risk prediction and prevention methods as scientific practices. Our findings offer insights into the possible ways in which disaster education and science education can be integrated in the context of secondary education.

Parallel Session - 10.5 (Symposium)

09:00 - 11:00 Friday, 1st September, 2023

58 Opportunities and Challenges of Modeling-Based Science Education

Chair

Digna Couso

Discussant

Costas Constantinou

Abstract

There is a strong and widespread recognition that modelling is a core practice in both science and science education. As such modeling, understood as the construction of models in the classroom to learn both science and about science, has been the focus of extensive research efforts in our field. Unsurprisingly, outcomes of this research usually depict modelling as very challenging but promisingly effective to promote students' learning. In the present symposium, the aim of the four presentations is to focus on different aspects of modelling that are crucial to its theoretical interpretation, and which have strong implications for modelling-based instruction in practice. Along the symposium we will navigate different perspectives to models and modelling, including the philosophical, conceptual, affective and linguistic perspectives applied to modelling-based science education. This includes research-based proposals regarding critical issues in modelling-based teaching, such as: what sort of models should be the focus of our modelling efforts in the science classroom; what progression can guide our teaching of a particular scientific model along schooling; how is the teachers' discourse that mediates students' modeling practices and development of models, or what role does it have the affective dimension in modelling efforts in the classroom. These and other related questions will be the focus of the symposium, which will be centered on engaging a lively discussion on the opportunities and challenges that the diverse included perspectives can offer. As a result, the symposium will explore both theoretical and practical aspects of modeling through different types of research from different parts of the world, guided by a discussant with a long trajectory in the field of modeling-based instruction.

658 Analyzing the Relevance of Volition for Modeling

Moritz Krell[1], Rieke Ammoneit[1], Maximilian Göhner[2], Tom Bielik[3]

[1]IPN - Leibniz Institute for Science and Mathematics Education, Kiel, Germany. [2]FU Berlin, Berlin, Germany. [3]Beit Berl College, Beit Berl, Israel

Abstract

Definitions of modelling competence in science education do not yet include non-cognitive factors. However, non-cognitive factors are central to competence and might, thus, substantially improve our understanding of modelling competence. In this study, we analyze volition during preservice teachers' engagement with a black box modelling task and its relation to established aspects of modeling competence: metamodeling knowledge, modelling process, and modelling product. The participants were asked to think aloud, and the transcripts were analyzed for volition categories and established modeling competence variables. A cluster analysis of the occurrence of volition categories resulted in three clusters of volitional behavior. The clusters describe three volition types: one action-oriented type applying a self-regulative strategy and two state-oriented types applying self-controlling strategies. Further analyses indicate the benefits of the self-regulative strategy.

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787 Teachers' Discursive Strategies in a Model-Based Instruction Workshop

Camilo Vergara-Sandoval, Víctor López, Digna Couso

Universitat Autònoma de Barcelona, Bellaterra, Barcelona, Spain

Abstract

In this research we aim to characterise utterances that conform teachers' discourse that mediate the progression of the students' ideas, its formative assessment, and their participation in modeling practices in the context of a model-based workshop for high school students. Using a discourse analysis methodology, we characterised utterances present in the teachers' discourse through communicative acts. We also identified the modeling practices in which the students participate, which allowed us to identify different modeling practice chains, that promote different functions in relation to the students' ideas. Then, we identified four main kinds of different articulations and sequences of these communicative acts, i.e., discursive strategies, that shapes the teachers' discourse to encourage students to engage in discussions and specific modeling practices chains that promote the expression, questioning and advancement of their ideas. Through different examples teachers' utterances and communicative acts, we discuss the functions of discursive strategies in the development of students' ideas and their participation in modeling practices.

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825 Towards School Science Models Learning Progressions

Ainoa Marzabal[1], Franklin Manrique[2], Virginia Delgado[2], Cristian Merino[3]

[1]Pontificia Universidad Católica de Chile, Santiago de Chile, Región Metropolitana, Chile. [2]Pontificia Universidad Católica de Chile, Santiago, Región Metropolitana, Chile. [3]Pontificia Universidad Católica de Valparaíso, Valparaiso, Región de Valparaiso, Chile

Abstract

To overcome current curricular challenges, we propose to consider school scientific models as structuring nuclei of the school science curriculum. For this, an adequate selection and sequencing of scientific models that would be relevant to be addressed in schools is necessary. Even when there are previous research works that have proposed relevant scientific school models, and have studied how they evolve during schooling, these works are hardly convergent, and do not exhaustively cover the entire school science curriculum. With the purpose of contributing to integrate the works developed so far in a unifying framework, we present the case of the learning progression of the substance model as an example. Through an inferential content analysis, we were able to integrate the core ideas and components of the model, and the forms of chemical thinking in a learning progression. This learning progression was later refined from written responses of more than 400 students to an activity designed and validated for this purpose. As a result, we have a learning progression that represents the progressively more sophisticated stages of school-age students when facing learning situations within the substance model. The construction and empirical refinement of these learning progressions are proving to be fruitful as resources that can guide both curricular designs, as well as the design and management of modeling-oriented science teaching and learning sequences.

1009 The Notion of "Precursor Didactical Model": Considerations From the Philosophy of Science

Agustín Adúriz-Bravo

Universidad de Buenos Aires, Buenos Aires, Argentina. CONICET, Buenos Aires, Argentina

Abstract

The aim of this presentation is to sketch some theoretical considerations on the concept of "precursor (didactical) model", developed by French didactics of science (i.e., science education as a discipline). These considerations will be made with the aid of the epistemological notion of "theoretical model", using the characterisation of that notion provided by semanticist philosophy of science of the last quarter of the 20th century. The very concept of model, and its diverse theorisations, have become in the last three decades the object of much academic work in many disciplines. In particular, in recent and contemporary philosophy of science the concept has played a central role, and this fact has markedly influenced research in didactics of science for the last two decades. Generally defined, a precursor (didactical) model is a specific kind of conceptual model purposefully designed with a didactical objective: to teach science at school levels. Thus, its similarities and differences with what semanticist philosophy of science calls a theoretical model can be analysed in some detail, as it will be done in this presentation. At the same time, the notion of precursor model is in itself a theoretical model from the discipline of didactics of science. Accordingly -just as it is the case with any other scientific model-, the idea can only be fully understood against the backdrop of the conceptual and practical conditions in which it emerged, the research questions from which

it arose, and the theoretical frameworks that provided its foundations and "legitimacy". Reflecting on the nature and use of precursor models in science teaching entails delving into the large multidisciplinary area of research and innovation around models and modelling in science education; this presentation will make explicit connections to other modes of research into the topic, well-represented in this symposium.

Parallel Session - 10.6 (Symposium)

09:00 - 11:00 Friday, 1st September, 2023

60 Relevance of Science Education Across the World Perspective on Students' Interest in Science From Five Countries

Chair

Magnus Oskarsson

Discussant

Bulent Cavas

Abstract

This symposium present studies from "The Relevance of Science Education - Second (ROSES)" project, which is an international explorative and comparative research project gathering empirical evidence of affective factors with importance for learning science and technology (S&T) from a student point of view. ROSES is a continuation of the former ROSE project, (Schreiner & Sjøberg, 2019). In 2019 an updated ROSES questionnaire was presented at the ESERA conference (Oskarsson, Westman, & Jidesjö, 2019) and an invitation to researchers around the world to join was sent out. The ROSES master questionnaire contains different categories such as S&T content in and outside school, interest to learn, future job, environmental and sustainability challenges, social and digital media and informal S&T experiences (Jidesjö, Oskarsson, & Westman, 2020). This symposium present how preparatory work is done in different countries, which gives examples on how S&T is involved in various cultural contexts and discussions. It also provides examples of empirical analyses of data which illustrates how data and results can be used in different national settings. Paper 1 shows that perspectives from ROSE in Japan is very limited compared to impact from TIMSS both in policy and research, despite the importance of the affective domain. This establishment highlights the importance to strategically publish results of ongoing ROSES to fully utilize the findings from the impacts of TIMSS. Paper 2 describes that Georgian students demonstrate motivation and interest in learning S&T, they are engaged in extracurricular activities, use social media for study aims, are concerned with environmental problems and consider S&T classes interesting, but the levels of interest, motivation, interest and positive attitudes are not high and weakly connected to each other. The results of Paper 3 indicate that most students from the Amazon region in Brazil agree with positive statements about S&T, even when asked about the

importance of vaccination during the COVID-19 pandemic. Students from rural and urban areas also consider items related to "Art" as important for their future professions, which may be related to the cultural influence of the region. Paper 4 contributes with analyses of Spanish secondary students showing affective variables to correlate with recruitment to science, technology, engineering and mathematics. The results clearly point out and discuss student interest in early education as important for choosing a STEM career. Paper 5 is from Sweden, showing that students have different science identities correlated with different science capital. As an example, those who have experienced visits to science centres and museums and used online encyclopaedia, seen as signs of science capital, is coupled with an identity of critical trust in S&T and a willingness to engage in S&T issues (Archer, Dawson, DeWitt, Seakins, & Wong, 2015; Archer et al., 2010).

831 Swedish Secondary Student's Science Identity Coupled With Science Capital

Anna-Karin Westman[1], Anders Jidesjö[2], Magnus Oskarsson[1]

[1]Mid Sweden University, Sundsvall, Sweden. [2]Linköping University, Linköping, Sweden

Abstract

This paper presents how Swedish secondary student's science capital is coupled with science identity. The data is part of a large international research study called The Relevance of Science Education Second (ROSES) which aims to explore students' interest in, and motivation to learn, science and technology. The result identifies five science identities having different correlations with five factors of science capital. The study if framed by the theoretical development of an extended bourdieusian notion of capital together with science identity.

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884 Students' Interest and Attitudes to Science - Study Results from Georgia

Nino Javakhishvili, Marika Kapanadze, Lia Dzagania

Ilia State University, Tbilisi, Georgia

Abstract

Students' interest in science is an important issue for the modern learning and teaching process in many countries. The paper presents level of Georgian students' interests and attitudes to sciences. The study was conducted in the frames of the international ROSES project using ROSES questionnaire. Georgian students demonstrate motivation and interest in learning sciences, are engaged in extracurricular activities, use social media for study aims, are concerned with environmental problems and consider science classes interesting, but the levels of interest, motivation, interest and positive attitudes are not high and weakly connected to each other. More efforts are required from the policy makers, educators and curriculum experts in Georgia to conduct special measures for raising students' motivation and positive

attitudes to sciences.

1116 A Comparative Study of Impacts of ROSE in Japan in comparison with TIMSS

Shotaro Naganuma

Kyushu University, Fukuoka, Japan

Abstract

The current study aims to reveal impacts of ROSE in Japan in comparison with TIMSS on two aspects: science education policy making and science education research practices. A document analysis and a systematic literature review have revealed that influence of ROSE in Japan is very limited compared to TIMSS both on policy and research aspects. This study highlights the importance to strategically publicize the results of ongoing ROSES and to fully utilize the findings from the impacts of TIMSS.

957 Interests and Attitudes of Students From the Central Amazon (Brazil) About Science and Technology

Wallace Santos[1], Nelio Bizzo[1,2], Renata Alitto[1], Leonardo Araújo[1], Fernanda Franzolin[3], Paulo Sérgio Garcia[4], Paulo Monteiro[5], Isabela Nogueira[1], Paulo Sano[1], Rebeca Viana[1]

[1]USP, São Paulo, São Paulo, Brazil. [2]UNIFESP, Diadema, São Paulo, Brazil. [3]UFABC, Santo André, São Paulo, Brazil. [4]USCS, São Caetano do Sul, São Paulo, Brazil. [5]IBu, São Paulo, São Paulo, Brazil

Abstract

This paper presents the first results of the sample of the Relevance of Science Education – Second (ROSES) project carried out in 2022 with 88 students from a region of the central Amazon, Brazil. Following its mais objective, eliciting young people's attitudes and interests about Science and Technology, a questionnaire of 118 items was applied where students should, through a Likert-type scale, indicate a degree of agreement with the test phrases. The results indicate that most students agree with positive statements about Science and Technology, even when asked about the importance of vaccination during the COVID-19 pandemic. Students from rural and urban areas also consider items related to "Art" as important for their future professions, which may be related to the cultural influence of the region. Other items and variables still need to be analyzed, but the preliminary data from the sections presented in this paper corroborate the importance of ROSES to reveal different perceptions about Science and Technology, its relations with the opinions of young people, and also what they think about their professional future.

1155 Attitudinal Profiles of Young People's Scientific Vocation

Angel Vazquez-Alonso, Maria-Antonia Manassero-Mas

University of the Balearic Islands, Palma, Balearic Islands, Spain

Abstract

The small number of students choosing careers on science, technology, engineering and mathematics (STEM) and young people's participation in STEM have been ever a matter of international concern, due to the wide social and research implications for the relevance of science education (ROSE). This study explores the profiles of students' STEM choice through its relationship with science education affective variables, which are measured by means of a large attitudinal questionnaire (ROSES-Q) that targets STEM attitudes of 15-year-old students across the world. The results show that about 28% students agree to become a scientist and the comparison between the agreement and disagreement group across the ROSES items set up the items that may set up the prototypical profiles of future choosers and non-choosers of science careers by identifying the largest differences between them. For instance, choosers agree dramatically higher than non-choosers that school science is interesting, which obviously demand to teachers and researchers to strive to make school science more interesting to all. The authors expect to expand the results and the discussion at the conference, beyond the space limitations of this proposal.

Parallel Session - 10.9 (Symposium)

09:00 - 11:00 Friday, 1st September, 2023

18 Inquiry Teaching and Understanding in Iberoamerican Countries

Chair

Radu Bogdan Toma

Discussant

Pedro Membiela

Abstract

Education systems around the world are undergoing major educational reform to meet the needs of the twenty-first century. Given the results obtained by Ibero-American countries in the most recent PISA evaluation, with results in mathematics and science falling below the OECD average for Spain, Portugal, Colombia, and Chile, this is an urgent agenda. As a result, the goal of this symposium is to present some of the efforts being made in these four countries to reverse this trend, thereby increasing the visibility of Ibero-American science education research. The four proposals in this symposium address the construct that has been widely promoted in the literature for decades: scientific inquiry, conceptualized both as a means (i.e., inquiry as a

teaching approach commonly conceptualized as inquiry-based science teaching, problem-based learning, or project-based teaching) and as an end (i.e., epistemological understanding of the nature of scientific inquiry). Thus, the first proposal, from Spain, describes the design and development of an educational app aimed at encouraging the use of scientific inquiry. The usability results obtained with students in the fifth grade of primary education show that it is an easy-to-use and appreciated resource that may fill the gap in pedagogical resources for the enactment of inquiry as a teaching strategy. The second proposal, from Portugal, focuses on using project-based learning in secondary school to conceptualise scientific enquiry. It describes the results of a two-year longitudinal intervention aimed at improving and integrating key knowledge, critical thinking, and effective problem-solving strategies. The findings indicate that the intervention improved students' conceptual understanding as well as their critical thinking and collaboration skills. The third and fourth proposals address the epistemological aspect of inquiry. The Colombian proposal, in particular, focuses on teachers who use problem-based learning as their primary strategy for science teaching, analysing how the Aesthetic Dimensions of Knowledge emerge, which relates to aspects of scientific knowledge construction in the classroom. The results show a conflict between teachers' conceptualizations of problem-based learning and the development of scientific knowledge in the classroom. The Chilean proposal, on the other hand, describes an intervention aimed at improving understanding of the Nature of Scientific Inquiry and evaluating its relationship with science learning. The results show that the intervention was effective in improving epistemological understanding of scientific inquiry and that this understanding facilitates learning about science content related to natural and man-made disasters. Taken together, this symposium brings together valuable efforts being made in four Iberoamerican countries in order to improve science education. It is hoped that this will raise awareness of Iberoamerican science education research, informing and encouraging future studies on similar endeavours.

348 IndagApp: Development and Usability Evaluation of an App for Inquiry-Based Science Education in Spain

Iraya Yánez, Radu Bogdan Toma, Jesús Ángel Meneses-Villagrá

University of Burgos, Burgos, Spain

Abstract

This proposal describes the development of a 3D educational app for inquiry-based science learning in primary and secondary schools. A pilot study with Spanish 5th graders reveals adequate levels of usability. These findings are encouraging and suggest that the proposed app has educational potential that is worth investigating in further studies.

516 Project Based Learning as an Aesthetic Provocation to Contribute to Citizenship Education in Colombian Science Classrooms

Anlly Montoya[1], Katherine Acosta[2], Marlene Morales[2]

[1]Universidad de Antioquia, Medellín, Colombia. [2]Universidad de Tarapacá, Arica, Chile

Abstract

Project Based Learning (PBL) has been recently promoted as a powerful teaching tool that promote science learning using a multidisciplinary approach. Some authors also indicate that PBL is one variation of teaching science as inquiry. Despite the emphasis of using PBL in the classroom, little has been done to know how PBL may be used by science teachers and the aesthetic element that can lead to reflection on the role of the sensitive in the construction of students' knowledge. The purpose of this study was to explore how science teachers that use Project Based Learning (PBL) as a pedagogical-didactic strategy, accept the Aesthetic Dimension of Knowledge (ADK) as a provocative entity of the Citizen Education (CE). Three theoretical references support this study: 1) the Teaching of SE, from the approaches on the Nature of Scientific Knowledge. 2) the teaching of SE can be rising from personal development and critical thinking. 3) According to Ranciere (2015) the ADK allows "subjective" elements to emerge, which play a role in the acquisition and control of science, and which must also play a fundamental role in CE. The research adheres to the qualitative paradigm, hermeneutic-narrative approach, and the information collection instrument, its in-depth interviews and focus groups with four Colombian natural science teachers that work on PBL as scientific inquiry as a pedagogical-didactic strategy. The results allow us to identify the ADK as the possibility of the emergence of the questioning of the Ethos (established place). It is possible to envision: 1) A relationship between the rational and the sensible from the horizontality. 2) The emergence of the plurality and diversity. These elements are created from two integral events a priori: a) objectivity and competence from CE; (b) the narrative imagination; self-development, and Ethics from CE.

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493 The Impact of Understanding Scientific Inquiry on Learning About Natural and Human-Made Disasters in Chilean High School Students

Juan Jimenez[1], Edgard Hernández[2]

[1]University of Talca, Linares, Maule, Chile. [2]Ministry of Education, Santiago, Chile

Abstract

Nature of Scientific Inquiry (NOSI) is an important component of scientific literacy and an important educational objective in science education. Recent literature theorizes that NOSI increases students' understanding of science content knowledge. However, this assumption has yet to be tested empirically. The main purpose of this study was to empirically test the assumption that understanding NOSI improves learning about Natural and Human-Made Disasters (NHMD). Using a quasi-experimental, non-equivalent control group design, a sample of 150 11th-grade high school students from six classes in a large Chilean city were randomly

assigned to intervention and control groups via classroom clusters. Students in the intervention groups were given a special explicit and reflective five-week NOSI Unit, followed by a five-week NHMD-Unit, as a treatment. Those in the control groups received only the five-week NHMD-Unit. To measure their understanding of NOSI, and understanding about NHMD, students answered two valid and reliable instruments: The Views about Scientific Inquiry (VASI), and a multiple-choice NHMD-T. The results showed that the NOSI Unit was effective in improving the understanding of NOSI in the intervention groups. The results also showed that the NHMD-Unit was effective in improving the understanding of NHMD in both groups. However, students in the intervention groups outperformed their peers in the control groups by scoring higher on the NHMD-T. Further analysis revealed that students with informed views on NOSI achieved better scores on the NHMD-T than students with naive views, supporting the argument that understanding NOSI facilitates learning about NHMD. Taken together, the findings support the assumption that understanding NOSI improves learning about NHMD. Some limitations of this study include the remote context in which the study took place, and the potential bias in the qualitative analysis of the VASI questionnaires.

1079 Student Outcomes From Project-Based Learning: A Case Study of a Portuguese Secondary School

Rita Rocha[1], Luis Afonso[2], Pedro Assis[2,3], Paulo Moreira[4,5], José Lima[4,6], Regina Duarte[7]

[1]Colégio Luso-Francês, Porto, Portugal. [2]LIP - Laboratory of Instrumentation and Experimental Particle Physics, Lisbon, Portugal. [3]IST - Instituto Superior Técnico, Lisbon, Portugal. [4]Department of Electrical and Computer Engineering, Faculty of Engineering of the University of Porto, Porto, Portugal. [5]INESC TEC - Institute for Systems and Computer Engineering, Technology and Science, Porto, Portugal. [6]Research Centre in Digitalization and Intelligent Robotics, Polytechnic Institute of Bragança, Bragança, Portugal. [7]CESAM - Centre for Environmental and Marine Studies, Department of Chemistry, University of Aveiro, Aveiro, Portugal

Abstract

This study aims to analyze the potentialities of using Project-Based Learning [PjBL] as an approach to improve and integrate key knowledge, critical thinking and effective problem-solving strategies. A group of nine secondary students was asked to develop a project related to cargo ship exhaust emissions assessment in a harbor nearby the school. The project was develop along 2 years: the first year corresponded to the characterization of the problem and the ideation of a solution to be evaluated in the real context; the second year corresponded to the testing and improvement of the prototype. A Personal Meaning Map [PMM] was given to students at the beginning and at the end of the project to assess students' knowledge. Focus groups were used to assess critical thinking and peer cooperation, followed by semi-structured individual interviews. The results of PMM suggest that PjBL enhanced the number of words and conceptual categories to describe their understanding of the concepts, as well as the integration of words. Focus Group analysis revealed an enhancement in critical thinking and collaboration skills.

Parallel Session - 10.10 (Symposium)

09:00 - 11:00 Friday, 1st September, 2023

47 Identification of Successful Strategies During Problem Solving in STEM

Chair

Stefan Küchemann, Martin Rusek

Discussant

Iztok Devetak

Abstract

The symposium is a showcase of the SIG 7 Special Interest Group for Eye-tracking in Science Education Research. The studies included in the symposium focus on students' successful problem-solving strategies in STEM. The four contributions are joined by the methodology - they applied eye-tracking to bring more evidence. One contribution, a pre-post study, targeted the shift in medical and physics students' graph-reading skills after one semester. Another investigated how students learn about the concept of kinematics using multiple representations. The third study used eye-tracking to modify particulate animations in order to direct students' attention in a more efficient way. The fourth study combined eye-tracking, retrospective think-aloud and interviews focusing on students' procedure when ballancing chemical equations. It is obvious that traditional methods would provide only partial information about the studied phenomena. All of these studies bring new information to science didactics, while also providing examples of other methodological approaches to the use of eye-tracking in science education research.

1129 When the Left Doesn't Match the Right: Using Eye-Tracking to Map Students' Progress When Balancing Chemical Equations

Martin Rusek, Lucie Hamerská, Matina Tóthová

Charles University, Prague, Czech Republic

Abstract

Our previous research has shown that pre-service chemistry teachers' ability to perform calculations from chemical equations is at a relatively low level. As it is directly linked to the ability to balance chemical equations, further research has focused directly on this skill. The goal was to determine the extent to which particle composition knowledge correlates with students' ability to balance chemical equations. At the same time, the students' procedures and the level of these subject skills' teaching in secondary schools were mapped. Based on a series of pre-tests consisting of chemical calculations and the Particulate Nature of Matter test,

students (N = 11) were selected for a qualitative study. In it, they balanced three series of chemical equations at phet.colorado.edu were used for this purpose. This process was recorded with an eye camera, and followed by retrospective think aloud and interviews. Results showed that there is no correlation between knowledge of particle composition and ability to enumerate chemical equations. For students it is an isolated discipline for which they use learned algorithms. At the same time, it turned out that the supports in the applet in the form of molecular models or scales showing the balance of the number of given elements' atoms in reactants and products are not used by students at all - they only solve the symbolic side of the equation.

1133 What Matters More – Context or Discipline? Comparison of Graph Comprehension and Visual Strategies Between First-Year Physics and Medical Students

Verena Ruf

Ludwig-Maximilians-Universität, Munich, Germany

Abstract

The ability to interpret graphs correctly is an important aspect of mathematical skills. However, interpreting the relation between two variables based on their graphical representation can be hard for students – even at university level. Students' competence in this area seems to differ between the subjects they study and the context the graph is represented in. This study therefore compares physical and medical students in their first semester when answering graph items in the context of math, physics, and medicine. We analyze the attention distribution of participants by recording their eye movements while they solve the problems. There do not seem to be differences in answer correctness between physics and medical students in a medical problem. Regarding participants' attention distribution our results are in line with previous research, indicating that correct solvers look more often at the correct answer than incorrect solvers. Participants who solve the item correctly also focus more on the correct function label.

1137 Towards Adaptive Learning and Real-Time Feedback With Eye-Tracking

Stefan Küchemann

Ludwig Maximilian University, Munich, Germany

Abstract

In STEM education, learning with multiple external representations (MERs) is common in classrooms, textbooks, and digital materials. MERs provide information not just in text form, but also through mathematical, pictorial, or enactive representations. These representations have distinct advantages and are used to communicate complex scientific and mathematical concepts. Representational competence, which involves extracting information from MERs, switching between them, and creating knowledge, is crucial for learners to effectively use MERs.

Whether a learner will benefit from a specific representation depends on both the representation's features and the learner's representational competence. Despite the importance of representational competence, its interaction with MER features is yet to be researched. This study aims to examine this interaction by presenting learners with a basic instruction on kinematic concepts, supplemented by text, a static graph, or a dynamic graph. Therefore, we measure representational competence, conceptual learning gains, and use eye tracking to see how students with different levels of representational competence process information from different representations.

1139 Using Eye-Tracking Technology to Modify Particulate Animations for Guiding Attention

Sevil Akaygun[1], Jessica VandenPlas[2]

[1]Bogazici University, Istanbul, Turkey. [2]Grand Valley State University, Allendale, USA

Abstract

Understanding chemistry involves visualizing the interactions among the particles. These interactions have been modeled by particulate level animations which have been frequently used in chemistry classes. Previous studies have shown that even though animations help many students improve their understanding of chemical concepts, some students have difficulty in understanding what is presented because they cannot identify the salient features shown in the animations. Hence, students often view less useful features and miss important concepts. Eye-tracking technology can be used to identify which features may draw students' attention and which features are found to be relevant by the chemistry instructors. In addition to their chemistry knowledge, visual perception and spatial ability are the other constructs that may have an effect on how students view the animations. Therefore, using eye-tracking technology, this study aimed to identify the features that draw students' and instructors' attentions, so that the particulate animation can be modified to guide students' attentions by adding visual cues. In this study, seven instructors and twenty students voluntarily completed Redox Reactions Questionnaire (RRQ), Motor-free Visual Perceptions Test (MVPT) and Revised Purdue Spatial Visualization Test (ROT), and then viewed a particulate-level animation of a redox reaction. Interviews and retrospective think alouds were used to triangulate the eye-tracking data and probe understanding of the animations. The eye-tracking data, and the scores obtained from RRQ, MVPT, and ROT of the students and the instructors were compared by using ANOVA. Based on the comparisons in eye-tracking gaze data between these two populations, the animation was modified to help direct student attention and better meet student needs. The results will be discussed to shed light on how this data can help to improve multimedia curricular materials such as animations.

Parallel Session - 10.11 (Symposium)

09:00 - 11:00 Friday, 1st September, 2023

24 State of The Art of Research in Science Identities and Future Avenues. A Presentation Of The Book: Science Identities. Theory, Method, and Research

Chairs

Henriette Holmegaard, Angela Carlabrese Barton

Discussant

Heidi Carlone

Abstract

Research in Science Identities represents a burgeoning field of studies within science education. In the past decades identities studies have enhanced our understanding of how science learners' engagement and participation are produced in the interplay with power, and ideas of what counts as science knowledge. A strong focus has been on how the intersections of gender, social class, ethnicity, and other social axes, play a part in shaping the extent to which children, young people and adults come to experience science as being 'for me', or not, but also the extent to which they are recognized as science persons. This symposium presents four chapters from the edited book: Science Identities (Holmegaard, Archer; 2023). The aim is to provide insights into state of the art research, and display the breath of how different theoretical lenses within research in science identities, contribute with insights into different areas of science education research. In particular, the symposium will explore the link between identities, injustices and science that runs through the core of the book. The symposium presenters will have a particular focus on how they work with and studies identities. The presenters will draw on experiences from Canada, Denmark and United States, and within various settings: out of school spaces, disciplinary higher education practices and teacher education. The first contribution presents a qualitative case study of the activities within an afterschool space and girls-group activity. It offers a critical analysis of girl's engagement with science while paying particular attention to how the girls negotiated that space, its activities and science. The analysis presents three key themes hereunder the positioning of selves as science experts through the selected science practices. A discussion follows of how performances of gender led the girls engage in identity work around science on their own terms, they had no value beyond the club. The second contribution explores four aspects of community and citizen science (CCS) that that have potential to restructure science learning: contribution to scientific work, nested purposes, engagement with multiple practices, tools and roles, and place-based engagement. By analyzing two case-studies through a lens of identities-in-action, the proposal shows how CCS can support young people in seeing science and themselves in new ways, however at the same time reinforce prior notions of science as exclusionary or disconnected. The findings shed light on how educators can tailor their pedagogies to take advantage of the potential of CCS. The third contribution explores university students' negotiation of geoscience

identities in relation to the process of gaining recognised as performing disciplinary knowledge. The study applies ethnographic methods to approach students' learning-processes in fieldwork settings. The analysis present three themes hereunder practicing the interpretive nature of geology and 'strike and dip'. The discussion offers a critical perspectives on how students' learning and identity work intersect with narrow and tacit ideas of disciplinary knowledge and culture. The final contribution offer a framework to understand how new science teachers come to develop professional identities. In this framework, the elements of figured worlds, work in concert with the perceptions, actions, positioning, and agency as the grounding for the development of identity. The discussion argues how the framework support teacher's reflections on what is it about the worlds within which they are learning and working that align/do not align with those advocated by their programs and professional communities. The discussion will consider the identity lenses applied across the symposium and the knowledge-contribution of the book, and point towards future avenues for research in science identities as a field of research. There is much work still to do in science identity research, scholarship and activism.

168 Understanding Science Teacher Identity Development within the Figured Worlds of Schools

Gail Richmond

Michigan State University, Lansing, Michigan, USA

Abstract

In this presentation I summarize three goals of this work—first, summarizing how beginning science teachers develop a sense of who they are and what they can do as classroom educators—in other words, their professional identity; second, detailing how frameworks can help science teacher educators design experiences and supports to facilitate effective educator development; and third, articulating the process by which a theoretical framework can be developed and refined as a scholarly tool

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169 Can You Succeed in Geology Wearing Sneakers? Analysing Students Work in Higher Education

Lene Møller Madsen, Rie Hjørnegaard Malm

University of Copenhagen, Copenhagen, Denmark

Abstract

In this paper, we explore what is at stake for university students when negotiating a geoscience identity in relation to the process of establishing disciplinary knowledge. We use the concept of science identity to understand how students are recognised and how they negotiate their competence and belonging within the discipline of geology. By applying ethnographic methods, we study students' learning processes in different fieldwork settings. The findings are

illustrated with three portraits each exploring different aspects of students learning in the field: from understanding the interpretive nature of geology, learning the practise of 'strike and dip' to being able to 'see' as a geologist. We unfold how students' learning experiences and identity work intersect with disciplinary knowledge and culture. The analysis shows how science identity within a discipline takes many forms, both visible and tacit, and how it for the students requires identity work in relation to performing in specific ways in order to be recognised as competent within the discipline. We discuss how this narrow space for acknowledged performance is constituted in the disciplinary culture and why it is problematic. We advocate for a disciplinary culture that allows for an inclusion of different types of belonging and various ways of becoming a geologist.

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192 "It Was Always about Relationships and It was Awesome": Girls Performing Gender and Identity in an Out-Of-School-Time Science Conversation Club

Jrène Rahm[1], Allison Gonsalves[2]

[1]Université de Montréal, Montréal, Québec, Canada. [2]McGill University, Montréal, Québec, Canada

Abstract

In this presentation we describe girl's engagement with science within a structured afterschool space and girls group activity ConvoClub. We offer a critical analysis of engagement with science in the ConvoClub, paying particular attention to the manner the girls negotiated that space, its activities and science. A qualitative case study and co-design of the activities among six youth and its program director over the sixteen weeks led to the identification of three key themes: the building of solidarity around relationships through a digital storytelling activity; the co-opting of science through a collage, and the positioning of selves as science experts through the co-production of a video documentary with others in the club. We discuss how these performances of gender and identity led the girls engage in identity work around science on their own terms, they had no value beyond the club. The study offers rich insights into the broadening what we consider to be identity work in relation to science, and the urgent need to attend to its affective dimensions, both essential to support girls continued identification with science.

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402 Identites in Action: Opportunities and Risks of Identity Work in Community & Citizen Science

Heidi Lyn Ballard[1], Colin Dixon[2], Emily Harris[1]

[1]University of California, Davis, Davis, California, USA. [2]University of California, Davis, Davies, California, USA

Abstract

At its best, in community and citizen science (CCS) learning happens as a part of scientific work: Young people engage with new practices and tools as they generate data and knowledge used

by professional scientists, advocates, resource managers, and other decision makers. By expanding the roles youth may take up and allowing a diverse range of experiences to become relevant, CCS can disrupt narratives about who is and can be successful in science. In this piece, we describe four key aspects of CCS – contribution to scientific work, nested purposes, engagement with multiple practices, tools and roles, and place-based engagement – that have potential to restructure science learning. Analyzing two case studies through a lens of identities-in-action, we examine how these aspects afford unique opportunities, where they fall flat, and how youth exert agency to direct experiences in science toward meaningful practices and identities. The case studies detail how work in CCS can help young people see science and themselves in new ways, but can also reinforce prior notions of science as exclusionary or disconnected. The findings shed light on how educators can tailor their projects and pedagogies to take advantage of the potential of CCS.

Parallel Session - 10.12 (Symposium)

09:00 - 11:00 Friday, 1st September, 2023

69 Integrating Language and Science Education – Resources and Possibilities

Chair

Ronja Sowinski

Discussant

Kok-Sing Tang

Abstract

The important role of language in science education became more relevant within the past years in science education research with respect to scientific content learning and scientific literacy. Basically, this relevance is already visible within the scientific discourse community itself: Here, language serves to communicate, but it is also an important resource for meaning-making. Connecting scientific content learning and scientific literacy with multimodal meaning-making experiences and resources, thus, provides bridging pedagogies to develop cultural heritage for science education with an asset-based pedagogical perspective. This educational perspective has been guiding teachers, researchers and students to share useful content and language-integrated learning strategies across ethnic diversities and socio-cultural backgrounds. As language is a central element of learning, it essentially influences the development of students' knowledge. Students do not only have to understand the language itself but must also structure their knowledge and conceptions by using language. Therefore, students need to have a high level of language proficiency with respect to the language of instruction and scientific language to participate in science education and become part of the scientific discourse community. For this reason, the integration of language and content learning is indispensable in the classroom. In this symposium, we will discuss the role of various

factors and resources that impact the development of students' scientific literacy in science education. The four papers within this symposium are situated in different educational contexts, including Science & Technology education in primary schools in the Netherlands, biology education in German and Austrian high schools and CLIL classrooms in higher education in Hong Kong. Despite the different cultural and linguistic background of the four studies, they all foreground variables that affect the integration of language and content learning in science education. The first paper gives an overview of recent empirical research on the effects of integrated language and Science and Technology (S&T) interventions in primary schools on student achievement. This literature review of 19 studies demonstrated a wide variation in the study and intervention characteristics. The findings also demonstrated positive effects for all reported student learning outcome variables. Finally, the relationship between the characteristics of the intervention and effect sizes was analyzed, which showed that studies with certain characteristics (e.g., higher levels of integration) produced higher effect sizes. Framed by this literature review, we will then present two papers that report on empirical classroom examples for adopting visual scaffolds and spatial repertoires to leverage scientific literacy. As the first example, a study from Hong Kong clarifies the importance of using different linguistic repertoires within science education. The design-based research takes place in tertiary education and aims to build up the inclusive use of different scaffolding resources in laboratory settings. This study outlines the benefits and challenges of using different linguistic repertoires during science education. The second intervention study focuses on writing tasks in biology education in secondary high schools in Austria. This paper explores the impact of science education on students' scientific interlanguage development. More specifically, it investigates how students make use of different scaffolds in teaching materials. Within this presentation, the language of instruction will be focused. Closing this symposium, we will focus on the importance of students' different languages next to the language of instruction as well. Therefore, the connection between learning science and being aware of students' individual linguistic and cultural backgrounds is drawn. This exploratory study focuses on secondary school students with different first languages who are talking about different biological phenomena. By juxtaposing these studies conducted in various contexts, we critically present different approaches from different perspectives about the relevance of integrating language and science education.

1174 Effects of Integrated Language and Science and Technology Interventions in Primary Education

Miriam Knoef[1], Hanno van Keulen[2], Martine Gijsel[3], Adrie Visscher[1]

[1]University of Twente, Enschede, Netherlands. [2]Delft University of Technology, Delft, Netherlands. [3]Saxion University of Applied Sciences, Deventer, Netherlands

Abstract

Attention for linking Science and Technology (S&T) to language education in primary schools has increased due to growing insights into the convergence of S&T and language learning.

Various interventions have been designed to evaluate the effects of integrated language and S&T (ILS&T) curricula. However, they show a lot of variation and demonstrate varying effects. Moreover, modern perspectives on literacy learning emphasize the importance of authentic practices, such as inquiry-based science, to develop language skills. Although past reviews have performed comprehensive analyses, it is not yet possible to disentangle whether ILS&T is effective for enhancing student learning in both subject areas, especially when the focus is on inquiry- or design-based learning. Therefore, this review offers a systematic analysis of the effects of ILS&T interventions. A framework was developed for the potential moderators of ILS&T studies and interventions. 19 studies were included in this review. The findings indicate a wide variation. The effects of interventions were delineated by study characteristics and outcome variables by comparing the weighted mean effect sizes. The findings demonstrated evidence for the effectiveness of ILS&T instruction for all reported outcome variables (e.g., S&T knowledge, reading comprehension, vocabulary, etc.). Effect sizes tended to be higher for studies that adopted a quasi-experimental design, small sample size, and independent instruments, and for interventions with higher levels of integration, a shorter duration (12 weeks or less) and the inclusion of TPD activities. Although it remains difficult to determine which approach to ILS&T instruction enhances student learning most, the findings of this review can improve the quality of the design of ILS&T interventions.

1177 Exploring the Impact of Science Education on the Development of Students' Scientific Interlanguage in Writing Tasks

Johanna Taglieber

Universität Innsbruck, Innsbruck, Austria

Abstract

The aim of this paper is to explore the impact of science education on the development of students' scientific interlanguage, with a focus on writing tasks in high school biology classes. More specifically, it seeks to gain insights into how students make use of scaffolds provided by course materials and how their scientific interlanguage develops in their writing. To answer these questions, this paper triangulates findings from two small-scale intervention studies: Intervention A (5x50 min) prepares students (N=18, year 9) for an integrated writing task on antibiotic resistance, using concept mapping (CM) as one of the scaffolding techniques. Study A uses a pre-post-test design, including (i) a word association test, (ii) questionnaires, and (iii) a writing task. Intervention B (3x45 min) supports students (N~20, year 8) in writing and revision during a collaborative writing task on the carbon cycle, using 'help cards' as a scaffolding technique. Study B uses a case study design, including (i) participant observation, (ii) questionnaires, (iii) and a writing task. Preliminary data analysis (study A) shows that the intervention had a small positive effect on the syntax, independence, structure and coherence of the students' written products. The participants used the CM technique quite differently. In most of the cases, it helped them to add concepts to those mentioned in the reading text. However, their modifications of the reading text lead to a lower accuracy concerning biological content. Only few students used CM to identify and re-structure relevant information from the

reading text. Overall, this paper underlines that integrating language-learning activities into science education does not automatically lead to positive effects, but is influenced by several variables, including task- and learner variables.

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828 One Fits Them All? – Metaphors in Multilingual Biology Classes

Ronja Sowinski, Simone Abels

Leuphana University, Lueneburg, Germany

Abstract

Metaphors are a crucial factor in students' biological content learning as they are used to make abstract phenomena more comprehensible. Therefore, metaphors are used in biology education to support students' learning. However, metaphors might even impede the understanding of non-native speakers: They must not be understood literally, but in a transferred sense, and the usage of metaphors differs between different languages as well as cultures. So far, it is still unclear what impact different first languages have on students' use of metaphors with respect to their biological content learning. This study examines which metaphors students with different first languages use when talking about biological phenomena and to what extent and kind the metaphors differ. For this purpose, guided interviews with 10th grade students (15-17 years old) on two biological phenomena were conducted. As metaphors are mostly used to make abstract phenomena more comprehensible, the study compares students' metaphor use within an abstract (immunological processes) as well as an experienceable phenomenon (decomposition of leaves). Additionally, information about students' language biography was collected. The interviews are analysed by using a combination of two methods: First, Qualitative Content Analysis is used to structure the content of the interviews, and afterwards, the data was analysed by Metaphor Analysis to get a deeper insight into students' metaphor use while talking about different aspects of the phenomena. Using these methods, a deeper insight into the connection between content and language was gained. Results show that students who did not experience (parts of) the phenomena (experienceable as well as abstract) tend to use metaphors used by teachers or textbooks. Furthermore, as the "war metaphor" is commonly used while talking about immunological processes, it is remarkable that some students (explicitly) tend to avoid this kind of metaphor.

Parallel Session - 10.13 (WORKSHOP)

09:00 - 11:00 Friday, 1st September, 2023

1316 Internationalisation in Science Education supported by four pillars: Open Education, Responsible Research and Innovation, Open Science, and Open Schooling

Alexandra Okada

The Open University UK, Milton Keynes, Buckinghamshire, United Kingdom

Abstract

This workshop presents key principles for researchers, project managers, and the academic community interested in internationalisation supported by cross-national studies as a strategy for knowledge exchange in Science Education through responsible research and innovation. A significant gap is identified with a scarcity of studies on this topic. The research question focuses on how the openness movement can be a potential catalyst for internationalisation. The aim is to understand how open international cooperation can provide a supportive foundation for promoting knowledge exchange to enrich research and innovation in Science Education. Through a descriptive case study, the partnerships, and outputs of the EU funded projects, supported by networks, cooperative partnerships and co-investigation are examined focused on coordination and support actions, open research, and innovation. The results of this study highlight the key principles that have enabled the development of an instrument for analysing expanded internationalisation processes, grouped into four pillars: (1) Open Education, (2) Open Schooling, (3) Responsible Research and Innovation, and (4) Open Science.

Post-Conference WORKSHOP for Early Career Researchers

09:00 - 11:00 Friday, 1st September, 2023

1289 Learning to Write Successful Journal Manuscripts

Joseph Krajcık

Michigan State University, East Lansing, MI, USA

Abstract

In this preconference workshop, participants will learn how to write research manuscripts with the potential for publication that contributes to the field of science education. The goals of the workshop are to foster conversation and build shared knowledge on how to write manuscripts that make a difference in the field of science education. We will focus on creating new knowledge that moves theoretical and practical agendas forward. The workshop leader will

introduce the participants to all aspects of writing research manuscripts. The workshop will begin by discussing the relevance and impact of the manuscript on the field. The discussion will focus on significantly advancing understanding of science teaching and learning and what it takes for the manuscript to substantially impact the field. The workshop continues by demonstrating what makes an appropriate introduction and rationale for a study and what makes a good question. Participants will also learn what makes a good discussion section. Finally, the workshop will stress the importance of coherence. One feature of solid research papers is coherence. The introduction links to the rational and theoretical perspective, which leads to the questions of the study. The design and analysis align with the questions. Finally, the discussion links back to the rationale and questions and points out explicitly how the new knowledge developed from the study. Finally, the implications must also link back to the purpose and rationale for coherence. Because many authors have English as a second language, the workshop will focus on providing writing tips by stressing writing in concise and clear language and that the manuscript is easy to read. The workshop leader will also make himself available for consultation. Disciplinary and Interdisciplinary Science Education (DISER) will sponsor the workshop.

Invited Panel - 2

11:30 - 12:30 Friday, 1st September, 2023

15 Challenges and Novel Solutions for Sustainable Future through Science Education

Chair

Özgül Yılmaz Tüzün

Discussants

Maija Aksela, M. Gabriela Lorenzo, Lilia Halim, Hsin-Kai Wu

Abstract

In this panel panelists present challenges and novel solutions for sustainable future through science education by considering the practices in four different countries. Practices cover Argentina, Finland, Taiwan, and Malaysia. From the interdisciplinary science teaching practices perspectives the panelists also present practices regarding science, technology, mathematics and engineering (STEM) in their countries. STEM education have been systemically considered as important strategy to improve the effectiveness of science education practices in many countries. In Malaysia this strategy has been considered since 2013, through formal, nonformal and informal education. Implemented STEM programs and outcomes of the initiatives in promoting STEM education in a diverse and multiracial country like Malaysia will be shared along with insights in understanding of the cultural complexities and realities of recruiting and retaining diverse students in STEM education. Similarly, practices in Finland regarding STEM

education are implemented based on the vision of the Finnish National Strategy for Mathematics, Science and Technology (LUMA) until the year 2030. LUMA and how this program is promoted to build novel research-based solutions for a good and sustainable future collaboratively through Finnish LUMA ecosystem will be explained. Science education practices in Argentina are influenced by several factors. The cultural heritage of Latin America in comparison with the rest of the world where language is particularly important, the unbalance of the research about teaching and learning science in different educational levels, and the clash of traditional or interdisciplinary (STEM, STS) teaching approaches will be presented. As a technology island, Taiwan highly esteems STEM education, recognizing it as the cornerstone of our economy. Integrated STEM activities have gained widespread popularity among parents and after-school programs. Nevertheless, within formal school settings, STEM education is not interdisciplinary. In the most recent Curriculum Guidelines for 12-year Basic Education, science, technology, and mathematics are treated as distinct and separate learning domains. How science education practices in Taiwan are shaped by these curriculum guidelines and contextual factors will be presented.

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291 Strengthening STEM Education in Malaysia: Initiatives and Opportunities

Lilia Halim

UKM, Bangi, Selangor, Malaysia

Abstract

Efforts on promoting STEM education have been systemically done in Malaysia since 2013, through formal, nonformal and informal education. This presentation aims to highlight the programs and outcomes of the initiatives in promoting STEM education in a diverse and multiracial country like Malaysia. Opportunities for further strengthening STEM education align with meeting SDG 4 are offered based on the review and research outcomes on STEM education. Experiences in the implementation of STEM education in Malaysia will offer insights in understanding of the cultural complexities and realities of recruiting and retaining diverse students in STEM education, allowing others to extrapolate the possible challenges and appropriate practices for designing and implementing STEM education in practice.

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323 Outlooks from Latin America on Science Education: State of Affairs and Actions for the Hereafter

María-Gabriela Lorenzo

Universidad de Buenos Aires, Buenos Aires, Argentina. Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Buenos Aires, Argentina

Abstract

The purpose of this work is to make visible some particularities in Spanish-speaking countries of Latin America as a source of some tensions in order to reflect about them, to review some actions performed in Argentina, and finally, to offer some possible course of action to the future.

Science Education teaching and research are influenced by several factors such as the particular cultural heritage of Latin America in comparison with the rest of the world where language is particularly important; the unbalance of the research about teaching and learning Science among the different educative levels (Secondary School, Teacher Education and Scientific-Technologic University Careers); the nature of initial formation of Science Education researchers (General Pedagogues or Natural Scientists); and the clash of traditional or interdisciplinary (STEM, STS) teaching approaches. In order to overcome these constraints some actions were implemented in Argentina. To improve Science Teaching and Research a broad variety of in-services teachers' training and post-graduated (doctoral and master studies) programmes are offered throughout the Country. In the same line, new Science teachers and researchers were created. They are: CONGRIDEC (Argentine scope) and MIDEC (Inter-American scope). In addition, Extended Laboratory Model is proposed as a new source of inspiration and resources to cover experimental nature of Science teaching. Finally, to set up interdisciplinary, mixed, multilevel and international working groups are posed as a good strategy to increase the Science Education research and to improve Science teaching and learning.

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667 Engaging Makers of Future on Math, Science and Technology Education Through Finnish Luma Ecosystem

Maija Aksela

University of Helsinki, Helsinki, Finland

Abstract

Science is for everyone! The aim of this presentation is to open the aims of math, science education and technology education based on the vision of the Finnish National Strategy for Mathematics, Science and Technology (LUMA) until the year 2030, and how we promote them by building novel research-based solutions for a good and sustainable future collaboratively through our Finnish LUMA ecosystem (11 universities, 13 LUMA Centres). This network has a special national task assigned by the Finnish Ministry of Education and Culture. Together we are more! (our LUMA motto)

Post-Conference WORKSHOP for Early Career Researchers

11:30 - 12:30 Friday, 1st September, 2023

1289 Learning to Write Successful Journal Manuscripts

Joseph Krajcık

Michigan State University, East Lansing, MI, USA

Abstract

In this preconference workshop, participants will learn how to write research manuscripts with the potential for publication that contributes to the field of science education. The goals of the workshop are to foster conversation and build shared knowledge on how to write manuscripts that make a difference in the field of science education. We will focus on creating new knowledge that moves theoretical and practical agendas forward. The workshop leader will introduce the participants to all aspects of writing research manuscripts. The workshop will begin by discussing the relevance and impact of the manuscript on the field. The discussion will focus on significantly advancing understanding of science teaching and learning and what it takes for the manuscript to substantially impact the field. The workshop continues by demonstrating what makes an appropriate introduction and rationale for a study and what makes a good question. Participants will also learn what makes a good discussion section. Finally, the workshop will stress the importance of coherence. One feature of solid research papers is coherence. The introduction links to the rational and theoretical perspective, which leads to the questions of the study. The design and analysis align with the questions. Finally, the discussion links back to the rationale and questions and points out explicitly how the new knowledge developed from the study. Finally, the implications must also link back to the purpose and rationale for coherence. Because many authors have English as a second language, the workshop will focus on providing writing tips by stressing writing in concise and clear language and that the manuscript is easy to read. The workshop leader will also make himself available for consultation. Disciplinary and Interdisciplinary Science Education (DISER) will sponsor the workshop.

Virtual Parallel Session - 1.1 (Oral Presentations)

13:00 - 14:30 Friday, 1st September, 2023

Chair: Olga Mayoral

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84 What are High School Students' Mental Representations about Relativity Theory?

Maira Souza, Agostinho Serrano, Juliana Anjos

Lutheran University of Brazil (ULBRA), Canoas, Rio Grande do Sul, Brazil

Abstract

Considering the importance of Modern Physics themes approaches in basic education, this research discusses some results obtained after the development of activities with high school students involving both Special and General Relativity Theory. Since this theory requires a high capacity for abstraction, the development of mental representations by students could be a helpful tool for its comprehension. Therefore, an analysis was developed through video recordings of students aiming to identify what mental representations they use in the process of comprehension of Relativity. It was possible to identify both verbal (propositional) and non-verbal (imagistic) mental representations for different situations. The results are in accordance with the proposed by the Dual Coding Theory since the students used both coding systems.

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784 Exploring Students' Reasoning When Interpreting Epigenetic Visual Representations at Different Levels of Biological Organization

Annika Thyberg

Karlstads University, Karlstad, Sweden

Abstract

Epigenetics is an important emerging concept in genetics education. In communicating biology, external representations depict essential visual features and symbolism that help students understand epigenetic phenomena. This study explores how students interact and reason with different visualizations that communicate epigenetic phenomena presented at different levels of biological organization and modes of representation. The aim of the study is to investigate how different modes of visual representations depicted at different organizational levels mediate students' meaning making of epigenetic concepts. The CRM model was used as an analytical tool to identify students' interpretation of the visualizations. In an exploratory approach, 13 students interpreted and discussed six visualizations representing different levels of biological organization at various degrees of abstraction for about 20 minutes as part of semi-structured focus group interviews. The results show that the representation mode and depicted biological organization level influence students' meaning-making of epigenetics when reasoning with multiple visualizations. Previous research has shown that

students' interpretation ability of abstract science concepts is supported by the use of different representations. This study concludes that supporting this interpretation ability in an epigenetics education context is dependent on the use of different modes communicated at various levels of biological organization.

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814 The Impact of Multimodal Teaching on Students' Creative Problem-Solving in the Context of Biological Problems

Eliza Rybska[1], Shaaron Ainsworth[2], Jelle Boeve-de Pauw[3]

[1]Adam Mickiewicz University, Poznań, Poland. [2]The University of Nottingham, Nottingham, United Kingdom. [3]Utrecht University, Utrecht, Netherlands

Abstract

Creativity is widely found to be an important characteristic within student (science) learning, yet it has also been shown to decrease as students progress through the educational system. With boosting creativity in mind, we designed multi-modal lessons that allowed students to gain experience with taught objects via many modes of communication and creative problem-solving whilst studying four different species. We evaluated the effectiveness of this pedagogic strategy in terms of its impact on students' creative problem-solving in the context of biological problems. 5159 students (grades 1-6) participated in the research, 774 of which in lessons without a multimodal environment (50 classes), and 4385 (185 classes) in lessons with multimodal tools, and environment (including drawing activity). Drawings of biological problem-solving were analyzed for features of creativity proposed by Guilford (1950), namely fluency, originality and flexibility. Our results showed that the multimodal teaching intervention have (medium to) large effects on all aspects of creativity and on all species in the intervention.

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992 Are the SDGs Present in the Initial Training of Early Childhood Education Teachers?: The Case of the University of Valencia

Olga Mayoral, José Cantó, M.Àngels Ull, Maria Calero, Tatiana Pina, Amparo Vilches

University of Valencia, Valencia, Spain

Abstract

This study is part of a broader investigation on the contribution of Higher Education to SDGs teacher training. In this case, the initial training of Early Childhood Education teachers is analyzed. The methodology entailed reviewing all the teaching guides of the subjects included in the university degree, to identify each of their competences that effectively contribute to the SDGs. The results show that many SDGs are not addressed by any subject and that it is mostly done in the first two years when specific didactics are less present in the study plan. The results of this study provide the opportunity to reflect on the changes that need to be made to the curriculum to foster adequate incorporation of the SDGs in the professional competences of future Early Childhood Education teachers.

Virtual Parallel Session - 1.2 (Oral Presentations)

13:00 - 14:30 Friday, 1st September, 2023

Chair: Júlia Ogata

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200 STEAM Interventions with Inquiry and Contextualization Strategies

Teresa Lupión-Cobos, Cristina García-Ruiz

Universidad de Málaga, Málaga, Spain

Abstract

This experience describes an opportunity to approach STEM education in the Spanish system through teaching mentoring interventions in primary education. We describe a project designed to seek solutions to different challenges focusing on STEM perspectives describing its structure to operationalize teacher professional development, enhancing STEM integrative learning design competence, STEM disciplinary content knowledge, and reinforcing the development of students' key competencies. Also, we indicate findings produced and comment on the program's impact on the students and science school teachers.

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307 A STEAM Gamified-Activity in the Future Classroom Lab: Effect on Pre-Service Teachers' Emotions

Ana Isabel Montero Izquierdo, David González-Gómez, Félix Yllana-Prieto, Jin Su Jeong

Department of Science and Mathematics Education, University of Extremadura, Cáceres, Spain

Abstract

It is known that emotions are essential in education and can act as barriers or facilitators in the teaching-learning process. Therefore, the importance to encourage a positive emotional climate in the classroom aims to support learning procedures. Another fundamental problem in current education is the teaching of separate subjects. Thus, the need to alter the conventional paradigm of teaching subjects individually has led to the development of science, technology, engineering, arts, and mathematics (STEAM) education. Therefore, to succeed as a citizen and employee in the twenty-first century, a person must develop 21st century competences. The Future Classroom Lab (FCL) is a space that favors learning by competencies, offering different learning areas in which students can investigate, interact, exchange, develop, create and present. In this research, it will be discussed a pedagogical intervention for combining teaching and learning through STEAM gamified activity in the FCL (science and mathematics), as well as the importance of emotions and their connections with the learning process. The purpose of this research is to quantify the emotions that pre-service teachers (PSTs) have regarding this pedagogical intervention in the FCL. A total of 54 PSTs participated

in the research. In terms of how the results were obtained, online questionnaires were provided, and data were gathered before and after the intervention. The existence of significant differences in the mean values of the analyzed variables was examined. The effect size was determined when relevant differences were found. According to the findings, the application of this particular intervention within the FCL has demonstrated a positive impact on PSTs' emotions. Despite this, the study's sample size is still modest. As a result, the sample size will be increased in subsequent studies to make the study more significant.

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993 The Current Narratives of Steam Education and How These Narratives Shape Transdisciplinary Science Education

Basak Helvaci Ozacar

University of Calgary, Calgary, Canada

Abstract

This paper aims to shed light on the ways STEM educators and researchers understand STEAM (science, technology, engineering, arts, and mathematics) and how this elucidation can inform science education practice. The overarching research question of this study is what are the current interpretations and implementations of STEAM education among STEM researchers as reflected in their publications. This study examines the current narratives, pedagogical alignments, and curricular choices in STEAM education through a literature review. This work also disentangles the unspoken or implicit academic and social orientations around STEAM education. Juxtaposing pedagogies through reflecting on the various implementations of STEAM within science education and pondering the implicit commitments of promoting STEAM education are some of the contributions.

1203 Social Representations of Elementary School Students About Risk Perception in the COVID-19 Pandemic

Júlia Ogata[1], Maurício Pietrocola[1], Ernani Rodrigues[2]

[1]São Paulo University, São Paulo, São Paulo, Brazil. [2]Federal University of Espirito Santo, Vitória, Espírito Santo, Brazil

Abstract

The objective of this work was to investigate the perception of manufactured risks of students of basic education, taking as analysis the São Paulo Plan, the plan to resume activities proposed by the State Government of São Paulo (Brazil) during the COVID-19 pandemic in the year of 2020. For this purpose, we use the contributions of the Social Representations Theory, by Moscovici, and the understanding of the Risk Society, by Ulrich Beck, as a theoretical reference. As a methodology, we use the Structural Approach of Social Representations, proposed by Abric. To produce the structure of social representations about the São Paulo Plan, we rely on the Free Word Association Technique. As a result, we obtained that students associate notions

of risks and dangers to the pandemic and, more specifically, to the São Paulo Plan. In addition, they reveal aspects that allow establishing that they still have an incipient understanding of the pandemic as a manufactured risk and outlining the importance of school content to understand the situations linked to the pandemic. In this way, the results of this work reinforce the potential to think and seek for a scientific education focused on the perspective of risks.

Virtual Parallel Session - 1.3 (Oral Presentations)

13:00 - 14:30 Friday, 1st September, 2023

Chair: Mariona Espinet

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890 Conceptual Understanding of Climate Change of German A-Level Students

Rainer Wackermann[1], Carina Wöhlke[1], Thomas Schubatzky[2], Claudia Haagen-Schützenhöfer[3], Jedamski Marko[1], Hannes Lindemann[1], Kai Cardinal[4]

[1]Ruhr-University, Bochum, Germany. [2]Innsbruck University, Innsbruck, Austria. [3]Karl-Franzens-Universität, Graz, Austria. [4]Duisburg-Essen University, Duisburg-Essen, Germany

Abstract

The anthropogenic climate change confronts humanity with unprecedented challenges. Understanding the scientific principles behind climate change is a prerequisite to reach higher acceptance of measures and to motivate individuals to climate-friendly behaviour. Concept inventories serve to reliably evaluate the understanding in large scale studies. Several such concept inventories exist, most recent addition is the up-to-date climate change concept inventory "CCCI-422" in German. The research aim is: Which student conceptions are prevalent among German A-level students at the end of formal schooling? And how do students rate their knowledge about climate change and how does their rating relate to their conceptual understanding? The sample consists of 501 A-level students of five German upper-level secondary schools. A student's conceptual understanding of climate change is defined as the person ability measured with the CCCI-422 using Rasch analysis. Students answered on average 14 of the 36 items correctly. Most difficult item with an item difficulty of 3.25 is the question, how high the percentage of greenhouse gases in the atmosphere is, with more than half of the students choosing between 5% and 55%. Also, roughly 30% of the students hold the false conception of the ozone hole being responsible for the strengthened greenhouse effect. On average, the students self-rate their knowledge pre 60% and post 33% after taking the inventory thus becoming more realistic. The correlation of person ability and pre- or post-self-assessment is in both cases significant, yet small in effect size. Overall, the CCCI-422 seems difficult for the A-level students, which sheds some light on all formal schooling in Germany.

1015 Multi-Intra-Inter Disciplinary Dimension for the Educational Reconstruction of Green Chemistry

Pía José González[1,2], Mariona Espinet[1], Anna Marbà[1]

[1]Universitat Autònoma de Barcelona, Barcelona, Spain. [2]Universidad de Chile, Santiago, Chile

Abstract

The introduction of Green Chemistry (GC) into school science curricula is considered an important step that encourages students to build connections between chemistry, other school subjects, and different aspects of their daily lives. This is because the concepts associated with GC can be applied throughout the different levels of education and offer a systematic approach to science for sustainability. In this study, with Chilean in-service teachers and science education researchers, we identify the school science subjects, school science contents, and crosscutting contents these participants link to GC. We use the Model of Educational Reconstruction as a theoretical framework. Our qualitative analysis leads to the identification of a model of curricular content for GC education. This model includes three different disciplinary dimensions such as the multidisciplinary dimension of school science subjects (chemistry (with the greatest presence), biology, physics, and geology; the intradisciplinary dimension linked to the core disciplinary contents; and the interdisciplinary dimension linked toa range of crosscutting contents. Regarding the participation of both in-service teachers and science education researchers, our findings indicate that this mixed approach brings additional robustness to the study of cutting-edge research topics, since they provide different perspectives on the construction of significant bodies of contents, for the teaching and learning Green Chemistry at school level.

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206 Youth Demands Experience-Based Learning for Tackling Climate Change, What Can Be Done: A Systematic Review of Research

Naz Fulya Çibik, Aylin ÇAM

Mugla Sitki Kocman University, Mugla, Turkey

Abstract

The climate change crisis brought on by pollution, biodiversity loss, and global warming endangers humankind's basic existence. Education reforms, therefore, are becoming more and more necessary to encourage people to adapt to and mitigate the effects of climate change. Despite having contributed the least to the climate change crisis, youth are/ and will be the group most affected by its effects. Therefore, it is essential to pay attention to their views and requests for generations that are better prepared for this situation. These people expressed a desire for participating actively in decision-making processes, work together with their peers, and participate in experiential activities to understand better the effects of climate change. In literature, research mostly focuses on climate change knowledge, which is found to be insufficient to equip youth with the decision-making and skills necessary to cope with climate change. To fill this gap, this study aims to conduct a systematic review of the literature and

research conducted particularly on climate change education and experiential learning. To this end, four electronic databases (ERIC, Google Scholar, SCOPUS, and Web of Science) were searched for papers that published on climate change and experiential learning. Findings show an increased interest in studying climate change education in experiential learning context which is more student-centered and experience-based. Studies focused on variables such as climate literacy, motivation, self-efficacy, and climate change knowledge. Inferences drawn upon the systematic literature review could be summarized as that it is crucial to take a practical, student-centered, experiential approach to increasing the involvement of youth in climate change-related issues and for more productive and immersive learning based on the participation of each student, and strengthened students' decision-making processes in climate change.

Virtual Parallel Session - 1.4 (Oral Presentations)

13:00 - 14:30 Friday, 1st September, 2023

Chair: Ernani Rodrigues

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794 Communities of Practice and the Elevation of Urban Elementary Teacher Discourse About Critical Pedagogy of Place

Gail Richmond[1], Roberta Hunter[1], Tali Tal[2], Grace Tukurah[1]

[1]Michigan State University, East Lansing, MI, USA. [2]Technion Israel Institute of Technology, Haifa, Israel

Abstract

Children who live in under-resourced communities and attend under-resourced schools deserve access to high-quality teachers and educational opportunities to support their success and well-being. This study emerged from a professional development (PD) for urban teachers working in such schools, to expand educational opportunities for elementary students through outdoor science teaching. Engaging frameworks of Communities of Practice (CoP) and Critical Pedagogy of Place (CPP), this critical ethnographic study investigates how urban elementary teachers engage in discourse about critical issues of place within a CoP. Additionally, the investigation seeks to understand how a CoP supports such discourse. The primary data for this study were multiple sets of researcher field notes collected from 6 participant teachers during spring weeklong summer PD. Over the course of the PD, participants shifted from viewing their outdoor teaching spaces through a deficit perspective to an asset focused one. As they visited one another's teaching sites, the CoP the teachers were part of allowed for discourse about social justice linked to issues of place within their respective school neighborhoods (CPP). The ability of urban elementary teachers to connect social justice to issues of place and to the teaching of science has implications for countering the injustice of lack that characterizes many

urban communities in the USA and elsewhere.

1237 Investigating the International Applicability of the MAVerBE Analysis Model

Ian Belinchon[1], Dennis Dietz[1], Claus Bolte[1], Mariona Espinet[2]

[1]Freie Universität Berlin, Berlin, Germany. [2]Universitat Autònoma de Barcelona, Barcelona, Spain

Abstract

This study's aim is to test if the MAVerBE analysis model can be adapted to a new linguistic context beyond the one of its conception, and still provide data. Based on theoretical considerations of constructivist learning theory, cognitive psychology and science education, MAVerBE focuses on measuring knowledge-linking in cognitive structures. To measure these structures in a Catalan City, the same procedure as that used to assess knowledge networks of German pupils related to the energy concept has been applied. The study's participants, secondary science students from the metropolitan area of a city in Catalonia, Spain, submitted an essay on the topic of energy, which was then analysed using a modified version of MAVerBE for the Catalan language. The results obtained show a comparable distribution of information chunks for the Catalan and the German participants, with relative level-specific vertical knowledge-linking differences. Part of these differences could be attributed to various factors bound to appear in an international comparison. The adaption of MAVerBE to the Catalan language posed no difficulty compared to the German version due to the heavy use of grammatical connectors and categories in the MAVerBE coding process, which are common in both languages. The demonstrated adaptability of MAVerBE to new linguistic contexts allows for the implementation of the model to analyse knowledge-linking in students internationally, opening the door to interesting comparisons in future investigations.

359 Recognizing Children's Funds of Science Knowledge

Kristen Schaffer[1], Lydia E. Carol-Ann Burke[2]

[1]Mount Royal University, Calgary, AB, Canada. [2]Ontario Institute for Studies in Education, University of Toronto, Toronto, ON, Canada

Abstract

Science educators are powerfully positioned to recognize children as science people, which in turn influences children's self-recognition within science. Based on this understanding, educators have sought to interrogate their own relationship to science and what it means to recognize science performed by another. We explore how an informal science educator employed an adaptation of Moll et al.'s (1992) funds of knowledge framework to better understand the myriad of ways a group of children expressed science. In this study, funds of science knowledge referred to the range of science knowledge, skills and resources children possess, and have access to in their families, communities, peers, and pop culture. The informal

science educator worked as a volunteer facilitator in an afterschool science club co-designed by the research team and a local science club provider. This study uses a critical practitioner research approach to examine the ways in which the volunteer facilitator recognized, misrecognized, and missed altogether children's funds of science knowledge in this setting. The findings report on the affordances and challenges of embracing an asset-based framework including: 1) shifting from deficit- to asset-based perspectives, and 2) examining how language matters and conveys this shift in stance. The paper ends by proposing how educators can employ similar asset-based, community-centred frameworks to promote greater equity as they unsettle their own powers of recognition in relation to children and science.

1151 Challenges in Curriculum Construction for Teaching Astronomy in Indigenous Culture in Southeast Brazil

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[1]University of São Paulo, São Paulo, São Paulo, Brazil. [2]Federal University of Espírito Santo, Vitória, Espírito Santo, Brazil

Abstract

Traditional knowledge has gained visibility in Science Education, with emphasis on the knowledge of cultural astronomy. It makes urgent the need for organizing the curriculum of indigenous and non-indigenous education, bringing together, in dialogue, both epistemologies. By observing the epistemologies of indigenous peoples, we seek to reflect on aspects of traditional astronomy and challenges for implementing it. We present possibilities to overcome colonial framework and to decolonize indigenous education in a region of Brazilian southwest. Given the timely moment curricular transformations can take advantage and parameters for respecting culture and dignity of indigenous populations in Brazil may be defined.

Virtual Parallel Session - 1.5 (Oral Presentations)

13:00 - 14:30 Friday, 1st September, 2023

Chair: Rahel Schmid

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267 The Effects of Virtual Community Engagements on Lesson Planning Competence amongst Pre-service Teachers

Denis Dyvee Errabo[1], Dave Arthur Robledo[2], Frosyl Miguel[2], Socorro Aguja[3], Prudente Maricar[2], Tetsuo Isozaki[1]

[1]Hiroshima University, Higashihiroshima, Hiroshima, Japan. [2]De La Salle University, Manila, National Capital Region, Philippines. [3]De La Salle Araneta University, Malabon, National Capital Region, Philippines

Abstract

As an active learning tool, lesson planning has stimulated educational innovation in Asia and Europe, leading to global reform in the educational system. Developing this competence raises awareness of the future of education. This study aims to support pre-service teachers' competence in lesson planning by engaging in a virtual community and sought to answer the question: 'How did pre-service teachers learn how to plan lessons in a virtual community?' The action research design was utilised to engage in collaborative virtual lesson planning and community dialogue. The study recruited pre-service teachers (PST) (n=6) to participate in a science education programme and requested community practitioners to facilitate. The interaction was held virtually and followed the community of inquiry framework. Virtual ethnography is a methodological approach to gathering participant observation data from field notes. The feedback from the interaction was selectively coded using quoting analysis and interpreted from a third-person perspective. The interpreted results were then analysed for theoretical contribution. The results found that engagement within a virtual community is dialogic, and participants practice reflexivity in acknowledging each other's personal and social identities. The engagement manifested self-determination, preserved the cultural identity of the teachers, and displayed the teachers' openness to change. Additionally, the engagement developed an understanding of ways to improve their practice by creating and co-creating relevant learning experiences, which often occur in the emerging learning environment, while reproducing practitioners' practices in online and remote learning.

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308 Teaching of STEM Concepts Through an Escape Room Approach

Félix Yllana-Prieto, Jin Su Jeong, Ana Isabel Montero Izquierdo, David González-Gómez

Department of Science and Mathematics Education, University of Extremadura, Cáceres, Spain

Abstract

The teaching of Science, Technology, Engineering, and Mathematics (STEM) has traditionally been challenging, particularly in scientific and mathematical content. To address this, new methodologies such as educational escape rooms can be utilized to improve students' knowledge and emotional engagement in STEM education. This study compares the effects of two educational escape rooms developed for learning science and mathematics content. For that reason, the knowledge, and the emotional factor (5 positive and 5 negative emotions) in trainee teachers have been analyzed after each escape room. The results show that there was a significant increase in theoretical grades after both escape rooms, with more improvement in the science escape room than in the mathematics escape room. Several emotions such as joy, fun, and nervousness are significantly higher after the science escape room, and the emotion fear is lower with respect to the mathematics escape room. To complete the study, a correlation analysis between knowledge and the different emotions was conducted. Hence, positive emotions enhance the trainee teachers' knowledge. According to the obtained findings, the two tools could have several benefits, with differences between disciplines, in the trainee

teachers' knowledge and emotional factor.

440 Digitalisation-Related Competences of Prospective Physics Teachers – How Do Student Teachers Use (Digital) Media in Physics Lessons?

Muriel Schaber, Gunnar Friege

Leibniz University Hannover, Hannover, Germany

Abstract

Current developments show that teachers need specific competences in dealing with digital devices and media * they are already essential and continue to gain in importance. The teacher training programme is of interest for the development of these professional competences. The use of (digital) media by future physics teachers is being investigated to accompany the physics teaching practicum in the Master's programme. This is being implemented as a qualitative study that looks at both the planning, the implementation in the classroom and the subsequent reflection of the students. The data will be analysed against the background of an integrative model developed from relevant competency models on the professional and digitalisation-related competencies of prospective (physics) teachers.

123 Understanding of Nature of Science and Dealing with Errors

Rahel Schmid[1], Nicolas Robin[1], Alexander Strahl[2]

[1]St.Gallen University of Teacher Education, St.Gallen, Switzerland. [2]University of Salzburg, Salzburg, Austria

Abstract

Errors are part of scientific knowledge acquisition and a characteristic of scientific knowledge. Therefore, they are an integral part of Nature of Science (NOS). Although Allchin (2012) made a proposal for teaching NOS through errors, errors are still under-emphasized in NOS. This study provides first empirical results on secondary school students' understanding of NOS and how they deal with errors in the context of STEM education. The question is investigated to what extent the students' understanding of NOS aspects influences the way they deal with errors. To answer the research question, students were surveyed with a questionnaire. The sample consisted of 269 secondary school students from the German-speaking part of Switzerland (grades 7 to 9). The results showed that secondary school students' understanding of NOS aspects has an effect on their error learning orientation. The results also showed that the effect of students' understanding of NOS aspects on affective-motivational responses to errors is mediated by error learning orientation. These results suggest that more importance should be given to errors as an aspect of NOS.

Virtual Parallel Session - 1.6 (Oral Presentations)

13:00 - 14:30 Friday, 1st September, 2023

Chair: Kim Blankendaal

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199 Integration of Technology in Learning Activity Designs: Case Studies

Andrea López, Alejandra Meneses

Pontificia Universidad Católica de Chile, Santiago de Chile, Chile

Abstract

The study examines technology-mediated activity designs created by high school science teachers from selected technology, the insights they orchestrate, and the contradictions that emerge from technology integration. From the framework of technological pedagogical and content knowledge (TPACK) and Activity Theory (TA), the designs were analyzed. The findings reported that teachers integrate specific technology into the content, but the learning goals they formulate are of low cognitive demand. The main contradictions were associated with teachers' knowledge, student characteristics, access to technology, and educational policies. Finally, recommendations are discussed, and requests are made to prepare teachers for effective technology integration.

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284 A Conceptual Framework for Digital Research Skills in Secondary Science Education

Kim Blankendaal, R. F. G. Meulenbroeks, W. R. van Joolingen

Utrecht University, Utrecht, Netherlands

Abstract

This study focuses on the perceived gap between the required and actual level of digital research skills (DRS) of students entering tertiary science education. A framework of DRS, incorporating seven categories, is evaluated using an exploratory qualitative study employing semi-structured interviews with university teachers (N = 15). The level of DRS at the start of university science education and university teachers' perceptions of first-year students' level of DRS have been investigated. The results show that the skills of writing a research paper using digital tools, using proper resources, and analyzing, transforming, and visualizing data were generally found to be wanting.

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310 Secondary Students Drawing Comics for Physics Learning

Evi Ketsea

CY Cergy Paris University, Paris, France. Laboratoire de Didactique André Revuz, Paris, France

Abstract

The objective of this study is to explore the potential benefits of students drawing comics on the learning of physics in the context of the secondary classroom. A design-based research study comprises the design and teaching of an interdisciplinary (physics and arts) lesson sequence in a class of a French secondary school (ages 14-15). Analysis of the comics production will use semiotic and didactics theoretical frameworks.

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549 Digital Research Skills: Application in Secondary Science Education

Kim Blankendaal, R.F.G. Meulenbroeks, W.R. van Joolingen

Utrecht University, Utrecht, Netherlands

Abstract

This study focuses on the current level of Digital Research Skills (DRS) as applied by pre-university science students. A rubric containing 6 categories and 38 categories was constructed and tested based on a DRS framework. 88 randomly collected students' science project examination reports were analysed using the rubric. The results show that students demonstrate difficulties in analysing, transforming and visualizing content/data digitally and writing a research paper using digital tools. For example, graphs in the reports frequently only contain a line without measurement points, while axis values are displayed inconsistently or are missing. Furthermore, formulas are often visualized without a proper format. To bridge the gap in the transition to an academic science study, more attention on DRS in secondary education is warranted.

Virtual Parallel Session - 1.7 (Oral Presentations)

13:00 - 14:30 Friday, 1st September, 2023

Chair: Georgios Ampatzidis

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222 Are Games Effective to Learn and Think about the Nature of Science in Primary Education?

Maria-Antonia Manassero-Mas, Angel Vazquez-Alonso

University of the Balearic Islands, Palma, Balearic Islands, Spain

Abstract

Nature of science (NoS) is a difficult issue to learn due to its metacognitive nature, the need to master thinking skills, poor teacher training, and lack of resources, which are especially acute in primary education. This paper studies the application of four epistemic games in primary classrooms, as cultural resources that may contribute to overcome those hindrances by gamifying scientific practice to teach NoS issues. The games and its use as didactic materials are described and the procedures include explicit and reflective pedagogy that develops scientific thinking skills. An attitudinal test on the image of science and technology (S&T) assesses the effectiveness of games through a pre-post-test research design. The results show that students improve their image of S&T, yet the changes are only significant in some specific aspects, such as the social importance of S&T, and girls' attitudes tend to improve more than boys. The successes of games to teach NoS and to develop thinking, the consequences for learning, the limitations, and the flexibility and sustainability prospective features of games are discussed.

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346 Research Trends in Science Education From 2017 to 2021: A Content Analysis of Publications in ESERA Conference Proceedings

Georgios Ampatzidis[1], Anastasia Armeni[2]

[1]University of Thessaly, Volos, Greece. [2]University of Patras, Patras, Greece

Abstract

Insight of research trends, as reflected in academic publications, is important for researchers. Systematic content analyses of articles published in academic journals related to science education have been carried out to this purpose. However, it seems that analyses of the proceedings of science education conferences are scarce. This study's objective was to compile, organize, and offer a cogent summary of ESERA's research activity over the previous six years. We report on the nationality of participating authors and the frequencies of topic categories of articles published in the proceedings of ESERA 2017, ESERA 2019 and ESERA 2021 conferences. Finally, we discuss relevant trends and emerging patterns.

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690 Towards Sustainable Practices: Bridging Plastic Cultural Heritage and Science Education in Museums

Aura Colliander

University of Turku, Turku, Finland

Abstract

Plastics are all around us as objects and artefacts in every-day use, news about plastic gyres in the oceans and research on the spread and effects of microplastics. Plastics have been in wide use for less than a century and hence plastic cultural heritage is only an emerging field of study within heritage studies. Plastics have already found their ways into cultural heritage institutions

such as museums, and their short lifespan has been discovered to be causing challenges for the established strategies of safeguarding tangible heritage in museums. In this paper I will build a bridge between plastic cultural heritage and science education and as a result show how the degradation of plastic heritage in museum collections could become a fruitful educational resource. With post qualitative inquiry I start building the bridge in the following way: I first identify some of the characteristics of plastic objects that are produced for long-term use. I then discuss how they behave and can be managed in museums as objects chosen to be preserved for the long-term. This is followed by identifying some of the sustainability issues that emerge in the current approaches to the long-term preservation of plastics. The theoretical approach is supported with examples of plastic artefacts from museum collections in Finland. I argue that museums could be excellent public educators, creating new knowledge on how to live on this planet with a new material that is on one hand very useful in every-day practices but harmful and challenging in the long-term.

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730 Insecurity and Knowledge About Inquiry Science Education: Initial Perceptions of Pre-Service Early Childhood Education

María Marta Alarcón-Orozco[1], Verónica Muñoz-Campos[2], Antonio-Joaquín Franco-Mariscal[2], Ángel Blanco-López[2], Jose-María Oliva-Martínez[3]

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Abstract

Different studies show that Early Childhood teachers show insecurity when carrying out inquiry activities. In order to study the relationship between insecurity and other key factors at the time of initial training, this paper analyzes the possible relationship with the perception of the level of knowledge that 117 pre-service Early Childhood teachers manifested on inquiry-based teaching before getting involved in a specific training program on inquiry. For data collection, a questionnaire was used in which pre-service Early Childhood teachers were asked to assess, individually, their level of knowledge about this scientific practice before and after presenting the program, and to indicate the emotions they had felt during the presentation of the program, as well as the cause for which they believe to experience it. The results obtained show that a third of the pre-service Early Childhood teachers feel insecure when facing a training program on inquiry and that the vast majority show a very low level of knowledge at the beginning of their training. The presentation of the program significantly improved their self-perception of knowledge about this methodology and those pre-service Early Childhood teachers who acknowledge having a lower level of knowledge are also the most insecure when facing a training program on inquiry

Virtual Parallel Session - 1.8 (Oral Presentations)

13:00 - 14:30 Friday, 1st September, 2023

Chair: Muriel Elaoumari

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962 Characterization of the History of STEM from the Perspective of Education Researchers

Katia Monica Verdim Eggert, Nicole Glock Maceno

Universidade do Estado de Santa Catarina (UDESC), Joinville, Santa Catarina, Brazil

Abstract

The present study aims to investigate and understand the elements of the history of STEM Education through a pilot research in national and international indexes that approach the teaching of Science, Technology and Education without temporal demarcation and analyzed by six descriptors for greater coverage of the bibliographical research. Fifteen studies were analyzed and showed divergences about the events and contextual circumstances that influenced the use of STEM projects in Science Education today. The surveys reported few historical elements about STEM, however, they show an increase in the integrative experiences used mainly by the insertion of Art, in the use in planning in Elementary Education and its inclusion in the Brazilian national curricular guidelines.

1192 The Ecodidactic Garden in the Initial Training of Teachers: Pedagogical, Scientific and Intercultural Value

Elizabeth Rodriguez Acevedo

Universidad Autónoma de Barcelona, Barcelona, Spain

Abstract

Universities continue in the search for a transformative and quality education, through educational innovation and initiatives that generate the development of didactic projects that make it possible to update, improve and include new practices to improve student training (Feixas et al., 2022). Pandemics, the food and energy crisis, climate change, migration, environmental pollution, wars and the loss of biodiversity are some of the problems that teachers have to face from their pedagogical practice, which implies having to rethink methodological strategies for these times of change, due to the fundamental role they play in schools. The study seeks to find out the pedagogical value that university teachers assign to the Ecodidactic Garden (HED), from their experience in the initial training of infant and primary school teachers and its use as a pedagogical resource in the different Spanish universities where they work to promote scientific and intercultural education. A qualitative, interpretative methodology was used, with the development of a structured interview script for the collection of information. Five lecturers in Didactics of Experimental Sciences who are part of the National

Network of Spanish Cultured Universities (RUC) took part in the research. The data obtained were analysed using Atlas.ti and organised into categories (8) and dimensions (3). The results highlight the pedagogical value of HEDs that are related to the interaction with the socio-historical-cultural context and the importance of safeguarding the biocultural memory.

31 Teachers' Storytelling Production for Teaching Science with Sensitivity to Cultural Diversity

Geilsa Costa Santos Baptista[1], Rosa Branca Tracana[2], Graça Simões de Carvalho[3]

[1]State University of Feira de Santana, Feira de Santana, Bahia, Brazil. [2]Polytechnic Institute of Guarda, Guarda, Guarda, Portugal. [3]University of Minho, Braga, Braga, Portugal

Abstract

This paper presents the results of a research that analysed how future science teachers' production of short stories can contribute to their training to be sensitive to the cultural diversity of classrooms. The methodology was qualitative, and data collection was carried out through a workshop on short story production with the participation of future teachers who attended the Basic Education undergraduate course at the Polytechnic Institute of Guarda, Portugal, with subsequent documentary and descriptive analysis. The results reveal that the participants were able to organise different cultural knowledge about nature to build their short stories. Furthermore, epistemological and ontological differences could be related to school scientific knowledge. These relations and their implications for intercultural dialogue in science teaching are pointed out. This study showed that the construction of short stories helps future teachers to investigate and reflect in advance on which opportunities science teaching can provide for intercultural dialogue in classrooms when scientific knowledge is related to other forms of knowledge.

1043 Hypotheses Production in Scientific Reasoning of French Primary School Pupils: Assessment of Astronomy Vocabulary

Muriel Elaoumari, Corinne Jegou, Maria-Antonietta Impedovo

ADEF AIX-Marseille University, Marseille, France

Abstract

This study is part of a more extensive study of the scientific reasoning of 9 to 11 years old French students. The analysis presented is centered on the step of hypotheses production inside the inquiry pedagogical method. This study aims to assess the impact of students' specific vocabulary skills on the ability to formulate hypotheses. The methodology is based on a "paper-and-pencil" test assessing the hypotheses step before and after the astronomy lesson in the science program. The first and second test evaluates the specific vocabulary in astronomy and correlates with the results concerning the hypotheses production. The first results show a significant relationship between high skills in scientific reasoning and a high score in specific

vocabulary. This result suggests that hypothesizing could be related to a prior specific vocabulary level.

Virtual Parallel Session - 1.9 (Oral Presentations)

13:00 - 14:30 Friday, 1st September, 2023

Chair: Sally B. Gutierez

914 Examination of Effects of Authentic Scientific Inquiry Experiences on Students' Epistemological Beliefs

Feral Ogan-Bekiroglu, Ozlem Goreci-Keskin

Marmara University, Istanbul, Turkey

Abstract

Epistemological belief is a psychological construct that refers broadly to individual conceptions and theories of the nature of knowledge and knowing. Although evidence suggests that students' beliefs change over time, it is not clear how epistemological beliefs change as a result of maturation or educational experience. The purpose of this study was to examine the effectiveness of authentic scientific inquiry on students' epistemological beliefs. Models-of-data theory framed this research. A pretest/posttest control group design was conducted to monitor the change in students' epistemological beliefs and to measure the effects of implementation of authentic scientific inquiry. The students' epistemological beliefs were measured with self-report questionnaire. Results showed that the students became more sophisticated in their beliefs about source and certainty of knowledge and development of knowledge dimensions. However, there was not any significant change in the students' justification of knowledge beliefs. this research suggests that more studies focusing on students' epistemic sophistication with the help of planned instructional modules would be done.

338 What Does It Take to Implement a Technology-Enhanced Inquiry Diffusion Unit in the 3rd-Grade Classroom? Challenges and Lessons Learned

Jessica Niewint-Gori[1], Tamar Fuhrman[2], Lorenzo Guasti[1], Livia Macedo[2], Paolo Blikstein[2]

[1]Indire, Florence, Tuscany, Italy. [2]Columbia Teachers College, New York, NY, USA

Abstract

Incorporating a new pedagogical approach, specifically technology-enhanced educational frameworks, at a traditional school is a complex process that involves many elements. This study examines the implementation of the Bifocal modeling approach in two Italian elementary school classrooms. This approach consists of inquiry-based pedagogy and technology-enhanced frameworks in the shape of computational scientific modeling. The research aims to

identify teachers' challenges when transitioning from traditional educational approaches to new pedagogical approaches guided by technology-enhanced inquiry-based teaching. The results show that novice teachers face challenges in three areas of knowledge: technology, pedagogy, and content. Therefore, teachers, specifically novice teachers, need scaffolding and professional development programs before implementing new pedagogical technology-enhanced approaches in the classroom.

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642 Analysing the Dynamic Demonstration of Representational Competence During Constructing Scientific Explanations

Qawiem Jamil[1,2], Joonhyeong Park[1], Tang Wee Teo[1]

[1]National Institute of Education, Nanyang Technological Univeristy, Singapore, Singapore. [2]Universiti Brunei Darussalam, Bandar Seri Begawan, Brunei Darussalam

Abstract

The purpose of this study is to investigate undergraduate students' constructed representations during the formation of scientific explanations to identify representations that provided them support during the task. The construction of scientific explanations is a major component of scientific practices and science education. It requires a careful orchestration of representations to complete successfully, which is a demonstration of representational competence. The literature has yet to offer a clear set of criteria by which to assess students' choices of representations. This study addresses that gap by identifying the characteristics of students' productive representations which supported them in forming coherent and accurate scientific explanations. A case study method was used, and a multimodal discourse analysis approach was taken to examine undergraduate students' demonstration of representational competence consisting of the disciplinary affordances, fidelity, and level of representations when they constructed scientific explanations. The results suggested that students that were supported were those that demonstrated representational competence by constructing high-fidelity representations with disciplinary affordances that provided access to accurate and relevant disciplinary meanings that act as anchor points. These include macro and sub-micro level representations of the phenomenon, or symbolic representations of established concepts and theories. These anchor points were utilized to construct, modify, or substantiate other representations to produce scientifically accurate and coherent explanations. These characteristics can be used as criteria to assess students' constructed representations during their articulation of scientific explanation to support achievement of coherence and accuracy.

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16 Epistemic Empathy as Emotionally Responsive Teaching that Fosters Students' Dignity while Experiencing Negative Emotions During Scientific Sense-Making

Sally B. Gutierez[1], Moonhyun Han[2]

[1]University of the Philippines Open University, Los Baños, Laguna, Philippines. [2]Seoul National University of Education, Seoul, Seoul, Korea, Republic of

Abstract

This qualitative study examines epistemic empathy as an emotionally responsive teaching strategy that fosters elementary school science students' dignity while they experience negative epistemic emotions during scientific sense-making of natural phenomena. Data included classroom audio and video recordings, student and teacher interviews, classroom observations, and recordings of the teachers' reflections in their community of practice. Results revealed that the teachers followed four steps in their actual provision of epistemic empathy: 1) noticing; 2) exploring the cause; 3) affirmation of students' emotions, and 4) providing cues to solve the problem. Their provision of epistemic empathy for the epistemic emotions of anger, anxiety, and confusion was facilitated by their reactive thinking as immediate adult decision-making during classroom interactions. Moreover, they upheld students' dignity in two ways: 1) by encouraging students to express their opinions, and 2) by listening and giving thoughtful responses to students' questions. The results provide implications that epistemic empathy can be an emotionally responsive teaching strategy to address students' negative epistemic emotions and uphold students' dignity when teachers allow them to feel like scientists.

Virtual Parallel Session - 1.10 (Oral Presentations)

13:00 - 14:30 Friday, 1st September, 2023

Chair: George Harb

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413 Pre-Service Teachers' Professional Vision of Gender-Relevant Aspects in Physics Teaching

Sanja Atanasova[1], Nicolas Robin[1], Dorothee Brovelli[2]

[1]University of Teacher Education, St.Gallen, Switzerland. [2]University of Teacher Education, Lucerne, Switzerland

Abstract

The professional vision (perception, interpretation, decision-making) of pre-service teachers regarding gender-relevant aspects is an important indicator for gender-sensitive teaching. Particularly in STEM teaching, especially in physics, gender stereotypes prevail, and gender inequalities are evident within different facets (e.g. teaching materials, teaching methods, interactions, teaching of physics content). The ability of teachers to perceive critical gender-relevant aspects and to react adequately to them is part of their professional competences and should already be developed during teacher training. This study aims to provide an insight into the professional vision of pre-service teachers regarding gender-sensitive physics teaching and to determine which factors are related to professional vision. Pre-service teachers (N=407) in Switzerland completed a questionnaire that captured their interest in gender-sensitive teaching and their learning opportunities on gender-sensitive teaching during their studies. In addition,

they completed a text-based vignette test that showed 16 critical, non-gender-sensitive situations from physics lessons in order to examine their professional vision of gender-relevant aspects. Multiple regression analyses were used to identify relevant factors. The results showed that learning opportunities about gender-sensitive teaching and the interest in it were related to higher levels of professional vision.

1285 Exploring Indicators of Science Teacher Quality: A Systematic Review

George Harb[1], Christine Preston[2]

[1]University of Technology Sydney, Sydney, New South Wales, Australia. [2]The University of Sydney, Sydney, NSW, Australia

Abstract

Many countries around the world are striving to foster high quality teaching in their schools. A deeper understanding of the indicators of quality science teachers will provide direction in defining practice, informing policy and future research. This study undertook a systematic review of literature to determine the research informed indicators of quality science schoolteachers. To identify relevant peer reviewed publications, six online, education-focused, databases were searched between 2011 and 2021. The identified publications were systematically reviewed, resulting in ninety individual publications being included in this study. Through content analysis, thirty indicator categories were identified as pertinent to science teacher quality. The most prevalent indicators were collaboration and relationship-building, reflective practice, self-efficacy, self-discipline, cultural competence, and values and attitudes. The results of this study have the potential to be used in numerous ways, including informing ITE programs, professional development for in-service science teachers, professional science education associations and education authorities.

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213 Development of Conceptual Framework for Assessing Critical Thinking Skills in STEM Education

Dennis Danipog, Jacqueline Rose Gutierrez, Haidee Rosete

University of the Philippines National Institute for Science and Mathematics Education Development, Quezon City, Metro Manila, Philippines

Abstract

STEM education has received growing attention worldwide. Education 2030 states that STEM and the development of 21st century skills should be given attention along with quality teaching and learning. One of the 21st century skills is critical thinking, as stated in the Incheon Declaration (World Education Forum, 2015). Undeniably, critical thinking skills are essential to overcome the new challenges that continually emerge in daily life, including rapid technological advancement. With this, it is important for our students to learn and develop critical thinking while learning STEM in schools in order to thrive in this world of new challenges. This research project is exploring digital approaches to the assessment of critical thinking skills

in STEM education, which may promote the development of such skills. To support the assessment and teaching of critical thinking skills in pre-tertiary STEM education, this research project aims to determine how a valid and reliable digital assessment can be designed to determine students' level of proficiency in certain quality criteria in critical thinking. The same assessment, when used at consecutive periods of time, may be mapped to a developmental progression of students in critical thinking skills. This paper presents the results of Phase 1 of this research project, a proposed conceptual framework for assessing critical thinking skills.

Virtual Parallel Session - 2.1 (Oral Presentations)

15:00 - 16:30 Friday, 1st September, 2023

Chair: Alejandro De la Hoz Serrano

684 Work and Self-Regulation Processes in an Online Task-Based Instruction on Newtonian Mechanics

Andreas Vorholzer[1], Jonas Gabi[2], Lukas Hunold[2], Claudia von Aufschnaiter[2], Julius Weckler[1,2], Alexander Eitel[2], Anna Kienitz[2], Joachim Stiensmeier-Pelster[2]

[1]Technical University Munich, School of Social Sciences and Technology, Munich, Germany. [2]Justus Liebig University Giessen, Giessen, Germany

Abstract

Online learning environments play an increasingly important role in science education. While they hold great promise for flexible and individualised learning, using such environments effectively also requires that students are able to self-regulate their learning. This study explores how students work and self-regulate their learning in a task-based, non-linear online learning environment on Newtonian mechanics. We investigate how students' activities are related to their dispositions and how dispositions and activities affect learning gains. The study employs a one-group pre-post design; the treatment comprises two 90-minutes learning sessions within the online learning environment. The learning environment consists of six units on different topics (e.g., basic properties of forces, multi-force systems) and different elements (e.g., explanations, tasks on three levels of difficulty, self-assessments). Data collected comprises students' content knowledge (pre- and posttest), self-regulation strategies, interest in physics, goal orientation, self-efficacy, and contingent self-esteem (pretest only). Furthermore, students' activities are captured via log files of their navigation in the environment, their solutions of tasks, their answers to self-assessments and short questionnaires about their experiences. The sample consists of N =35 first-year students with physics as a major subject. The statistical analyses of the data from this sample show significant learning gains of students. Interestingly, these gains correlate with students' work avoidance, but not with their prior knowledge or any other disposition assessed in the pretest. The analysis of the process data revealed that most students

use the learning environment in a linear way. Further analysis of individual activity patterns suggests two activity profiles but no clear relationship between these profiles and learning gains.

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858 How Do Pupils Interact With and Assess a Visual Learning Environment of the Carbon Cycle?

Marta Koć-Januchta, Gunnar Höst, Mina Mani, Måns Gezelius, Jonas Löwgren, Lena Tibell, Konrad Schönborn

Linköping University, Norrköping, Sweden

Abstract

One of the most important educational challenges in developing environmental literacy for sustainability is understanding systems thinking. For example, grasping the effects of humanity's disruption of the natural carbon cycle is crucial for making informed choices about climate change. Although development of systems thinking skills is challenging, they could be promoted through interactive visual learning environments. In the present study, we explore pupils' use and assessment of a newly developed interactive learning environment, termed "Tracing Carbon", designed to support grade 7-9 pupils' systems thinking skills in the context of the carbon cycle. Data were collected from two classes (n=63) that engaged with Tracing Carbon as part of their science class. Performance was assessed by analysing log files of interactive tasks. Further information was gathered from the number of errors and perceived difficulty in pupils' responses to quizzes in the system. The results indicate that the errors made when performing tasks can be related to misunderstandings such as believing that trees obtain their nutrition from the soil rather than from carbon dioxide in the air. Moreover, the quiz items that were designated "easy" were associated with fewer mistakes and a lower perceived difficulty rating than quiz items designated as "hard". Future qualitative analysis could reveal links between the hierarchy levels, the number and type of errors in both tasks and quizzes, and aspects of the communicated carbon cycle content.

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889 Tracing Carbon: Designing an Adaptive Visual Learning Environment to Develop Learners' Systems Thinking

Mina Mani, Måns Gezelius, Gunnar Höst, Marta Koc-Januchta, Jonas Löwgren, Lena Tibell, Konrad Schönborn

linköping University, Norrköping, Sweden

Abstract

Although there is an increasing emphasis on the importance of systems thinking skills in science education, there is little reported on the empirical design process of adaptive and interactive visual learning environments for developing these skills in classroom settings. Therefore, the purpose of this study is to provide a theoretically and teacher-informed design process of a learning environment that supports the development of grade 7-9 learners' systems thinking

skills in the context of the carbon cycle. To respond to this aim we describe our iterative and theory-based design process by highlighting the main design activities and the rationale behind them, including: 1) content conceptualisation, 2) pedagogical (teacher) input, and 3) adaptive characteristics. The outcome of this process has resulted in an adaptive interactive visual learning environment with multiple learning tasks and quizzes organised in three modules. Each module is designed with coherent learning objectives aligned with a hierarchy of systems thinking skills and the Swedish school curriculum. Focusing on the carbon cycle, our work aims to provide a personalised learning experience for learners in grade 7-9 in scaffolding different levels of systems thinking.

1173 Teaching Human Hydration Science Content Through Computacional Thinking and Educational Robotics

Alejandro De la Hoz Serrano[1], Andrés Álvarez Murillo[2], Lina Viviana Melo Niño[1], Javier Cubero Juánez[1], Florentina Cañada Cañada[1]

[1]Department of Didactics of Experimental Sciences and Mathematics. University of Extremadura, Badajoz, Spain. [2]Department of Didactics of Experimental Sciences and Mathematics. University of Extremadura, Cáceres, Spain

Abstract

The impact of technology has meant a change in the different educational plans of many countries, highlighting the inclusion of contents related to Computational Thinking and Educational Robotics, as a consequence of the multiple educational benefits they have. These terms are especially linked in Science Education, which is why teaching plans are needed to teach both contents in an integrated manner. The present study analyses the scientific knowledge about the habit of healthy hydration, as well as Computational Thinking skills/behaviours, after an intervention based on Educational Robotics and Challenge-Based Learning, in trainee teachers. The data analysis was carried out through a qualitative approach based on the robotic boards and reports that the participants were asked to produce. The data analysed reflect positive results on the scientific contents of hydration, especially those that reflect the volume of water consumed daily, with 71% and 64% of presence, although there is a low percentage on the contents related to the amount of glasses that correspond. There is also an adequate level of Computational Thinking skills/behaviours, with more than half of the sample in each behaviour. For all these reasons, activities based on Educational Robotics seem to be a suitable method for integrating scientific content and Computational Thinking skills at the same time, which is why we advocate further study in this line of research.

Virtual Parallel Session - 2.2 (Oral Presentations)

15:00 - 16:30 Friday, 1st September, 2023

Chair: Sonia Pamplona

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189 An Accessible Online Learning Environment with Hands-On Experiments to Foster Scientific Literacy

Martina Graichen, Silke Mikelskis-Seifert

University of Education, Freiburg, Germany

Abstract

The aim of the present study was to gain knowledge about a newly developed online learning environment. The learning environment was developed to promote experimental competences in science education (physics) on the topic of magnetism for all students, regardless of pupils' prerequisites. Therefore, the learning environment was developed largely in a comic style, considering both accessibility and stereotype-free aspects, including practical, non-dangerous experiments. After the students had worked on the learning environment, they rated the learning environment in terms of accessibility, the comic, cognitive load and answered a delayed knowledge test after about one week. The results show that the girls liked the comic style much better and that the perceived competence in dealing with the comic was higher among girls than among boys. In addition, the learning environment was perceived as very accessible and not cognitively overwhelming. The results show that the online learning environment can present Physics topics in a motivating, accessible way. At the same time, the newly designed learning environment promotes the interest of girls, which could counteract the common findings of lower interest in science content among girls.

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609 Understanding and Valuing Epistemic Criteria for Science News Evaluation in a "Post-Truth" World

Jessica Leung[1], Sarit Barzilai[2], Maurice Cheng[3], Polly Chik[1]

[1]The University of Hong Kong, Pokfulam, Hong Kong. [2]University of Haifa, Haifa, Israel. [3]The University of Waikato, Hamilton, New Zealand

Abstract

To critically read and evaluate (un)reliable science news, it is argued that laypeople should focus on the believability of experts rather than directly evaluating reported claims. This entails understanding the social practices of science – Who made the claim? To what extent is the claim accepted by the scientific community? Were the results published in a reputable, peer-reviewed research journal? Prior studies have shown that a practice-oriented approach guided by the Apt-AIR framework of epistemic growth is productive in promoting students' use of such epistemic criteria in their evaluation of science news. This experimental study extended prior

work by examining how this approach impacts students' metacognitive understanding and their valuing of epistemic criteria. 85 out of 120 students enrolled in a 12-week General Education undergraduate course, which aimed at preparing students for critical engagement with science news, participated in the study; 43 in the experimental group and 42 in the comparison group. The effects of participation were examined using various measures including epistemic criteria reflective tasks at pre- and posttest and follow-up interviews at delayed posttest, six weeks after the course. Our findings revealed that the Apt-AIR-guided practice-oriented approach led to greater understandings and valuing of epistemic criteria for science news evaluation compared to the comparison group. These findings provide a new perspective that goes beyond students' cognitive performance to encompass their metacognitive understanding and valuing of epistemic criteria, in turn, offering insights into why some students succeed and others fail in science news evaluation.

895 High School Students' Global Competence in the Context of Their Epistemological Beliefs and Motivation to Learn Chemistry

Márió Tibor Nagy[1,2], Erzsébet Korom[3,2], Zoltán Németh[4]

[1]Doctoral School of Education, University of Szeged, Szeged, Hungary. [2]MTA–SZTE Digital Learning Technologies Research Group, University of Szeged, Szeged, Hungary. [3]Department of Learning and Instruction, Institute of Education, University of Szeged, Szeged, Hungary. [4]Szent Gotthárd Secondary Grammar School, Szentgotthárd, Hungary

Abstract

Global competence (GC) is a crucial component of 21st-century education in our rapidly changing, interconnected, and diverse world. As important are critical thinking skills and the ability to evaluate information, which are closely linked to epistemological beliefs. Students' personal epistemology affects their motivation, engagement, and attitude towards science. This study investigates the relationship between global competence (GC), epistemological beliefs (EB), and motivation in the context of chemistry learning among Hungarian 10th-grade students (n=93). The results show that students have knowledge and interest in global issues, such as climate change, environmental sustainability or human rights. Significant positive correlations were found between global competence and two EB scales: development and justification. Furthermore, a link between global competence and self-determination has been identified. This research, and its future improvement, can aid in recognizing variables that can be included in upcoming programs aimed at enhancing global competence.

994 Science Purposes and Limits: Reflections of Trainee Teachers

Beatriz Pérez[1], Marta Reina[1], Marta Ceballos[1], José Eduardo Vílchez[1], Sonia Pamplona[2], Rafael Campillos[3], Ángel Ezquerra[2]

[1]Centro de Estudios Universitarios Cardenal Spínola CEU, Sevilla, Spain. [2]Universidad Complutense de Madrid, Madrid, Spain. [3]Universidad Camilo José Cela, Madrid, Spain

Abstract

The present study analyses the reflections of trainee teachers after a debate on daily situations in which science must intervene. 250 students from four Spanish university centres took part in the study and the analysis reveals a set of areas in everyday life where they consider that science should have a role (Health, Technology, Environment). Some went beyond the posed question and valued its purpose (practical, research, assessment) and the limits that should be imposed on science (ethical, environmental, evil use). These students' opinions could affect their future pedagogical performance.

Virtual Parallel Session - 2.3 (Oral Presentations)

15:00 - 16:30 Friday, 1st September, 2023

Chair: Rahel Schmid

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853 Two-Eyed Seeing - Bringing Science |Environment| Health Issues Into Science Teaching

Albert Zeyer

University of Teacher Education, Lucerne, Switzerland

Abstract

Science |Environment| Health (abbreviated as S|E|H) is a new science pedagogy with the vision of fostering a situation of mutual benefit between the three educational fields involved - science education, environmental education, and health education. In the last decade, and especially after the COVID-19 pandemic, there have been growing voices calling for a more holistic approach to S|E|H without losing the solid scientific grounding. It has been suggested that the philosophical concept of the stereoscopic view (Wilfrid Sellars), akin to the indigenous approach of two-eyed seeing (Elder Marshall), could help. This study uses action research with student science teachers to test and develop an existing framework of two-eyed seeing in science education. The process resulted in a refined model that proved to be a facilitating tool for the consistent development, presentation and evaluation of science teaching in relation to S|E|H issues.

1219 Calculation and Evaluation of Teacher Candidates' Ecological Footprints

Yunus Özyurt, Naciye Somuncu Demir, Pelin Aksüt Arslan

BAIBU Faculty of Education, Bolu, Turkey

Abstract

An important concept that has come to the fore with sustainable life has been the ecological footprint. While we are living our lives, we consume resources and produce waste until the end of our lives. This study; it is aimed to examine the footprints calculated with one-to-one application in order to raise awareness about the ecological footprint of the teacher candidates in the context of a sustainable environment in the Faculty of Education. In the study, the cross-sectional survey model, which is included in the descriptive (screening) research model, was used. This study is planned on all volunteer teacher candidates (Classroom Teaching, Mathematics Teaching, Special Education Teaching, English Language Teaching, Preschool Teaching, Music Teaching, Art Teaching, Science Teaching, and Social Studies Teaching) studying at the Faculty of Education at Bolu Abant İzzet Baysal University. It is planned to use a web-based individual "Ecological footprint calculation questionnaire" in order to calculate the ecological footprints of teacher candidates. Calculation made with the help of https://www.footprintcalculator.org/home/en website. Ecological footprint averages of teacher candidates using single sample t-test in the analysis of data, Turkey's ecological footprint average per capita stated in the "Living Traveling Report" published by the World Wide Fund for Nature (WWF) in 2010 is 2,7 gha will be compared.

1130 Service-Learning to Promote Food Waste Reduction in Primary School Education: A Case Study With Trainee Teachers

Maria Calero[1], Anna R. Esteve[1], Maria-Angeles Fernandez-Zamudio[2], Olga Mayoral[1], Tatiana Pina[1]

[1]Department of Experimental and Social Sciences Education, University of Valencia, Valencia, Valencia, Spain. [2]Centro Para el Desarrollo de la Agricultura Sostenible, Instituto Valenciano de Investigaciones Agrarias, Moncada, Valencia, Spain

Abstract

The purpose of this paper is to present some results of a broad research whose main aim is to contribute to raising awareness among Primary Education teachers in initial training on the necessary reduction of Food Waste. To this end, students of the Degree in Primary School Education at the University of Valencia have designed proposals based on teaching interventions for addressing this problem in an optional subject. These proposals have been implemented by in-service teachers with students in the 5th and 6th year of Primary School Education. The initial results show that the design and implementation of these proposals favour a significant knowledge about Food Waste on the part of the trainee teachers involved while helping, at the same time, to facilitate the incorporation of this topic in their future teaching practice.

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119 Out-of-School STEM Education Settings in Switzerland - A Use Analysis

Rahel Schmid, Nicolas Robin

St.Gallen University of Teacher Education, St.Gallen, Switzerland

Abstract

Over the past 25 years, numerous out-of-school STEM (Science, Technology, Engineering, Mathematics) settings have been initiated around the world. These are now an integral part of European culture and are actively used by teachers and students at different target levels. Various impact studies have shown short-term effects of such offers on cognitive performance, knowledge gain, comprehensibility or openness, interest, self-efficacy, motivation, and emotions. However, these effects are not sustainable. What is currently missing is an analysis of the use of these out-of-school STEM settings to contextualize their effects. Therefore, this study will investigate the use of STEM offers by teachers and by students to formulate measures for the further development of these out-of-school STEM settings. To this end, teachers and students from Switzerland will be surveyed with a questionnaire on their perceptions of STEM culture, on their attitudes towards STEM professions and on the use of out-of-school STEM settings after having visited an extracurricular STEM offer. In addition, interviews will be conducted with selected teachers. The first results of this study will be presented on the poster.

Virtual Parallel Session - 2.4 (Oral Presentations)

15:00 - 16:30 Friday, 1st September, 2023

Chair: Nurul Hassan Mohammad

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376 Science Teacher Identity Development: A Case Study in Physics

Nuril Munfaridah, Imas Aulia Salma, Endang Purwaningsih

Universitas Negeri Malang, Malang, Jawa Timur, Indonesia

Abstract

Research on the topic of teacher identity has been widely carried out in Indonesia, but has not developed much especially in the context of science education. Teacher identity is important for a teacher to know, in order to recognize and understand himself and his role as a teacher, so that teachers can decide the optimal steps to take in increasing professionalism. This study aims to examine the development of the science teacher identity of a physics teacher who has several roles such as teacher, wife, and mother. This study is a single case study of Sasa (pseudonym), 27-year-old female physics teacher who has a passion for teaching physics. The main data were collected through semi-structured interviews with the participant and confirmed to colleagues and students as a form of data triangulation. This study uses the construction of teacher identity which includes nine components, including physics' learning

experience; having knowledge & skills; community practices; science teaching practice; degrees of success; social respect; belief and value in science teaching; intrinsic satisfaction; and representations. The results of this study indicate that the knowledge gained through experience, commitment, and external support affects the construction of science teacher identity formed by a physics teacher. The passion to become physics teacher is the most dominant aspect in influencing her science teacher identity. Furthermore, the findings of this study can be used as a basis to find out how the construction of science teacher identity can be used so that concrete steps can be determined in the development of science teacher identity.

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414 The Effect of Gender-Neutral Looking Pedagogical Agents on Male and Female Students' Science Self-Concept.

Tom Jungbluth[1,2], Martina Graichen[1], Silke Mikelskis-Seifert[1], Josef Künsting[2]

[1]Freiburg University of Education, Institute of Chemistry, Physics and Technology Education, Department of Physics Education, Freiburg im Breisgau, Baden-Württemberg, Germany. [2]Freiburg University of Education, Institute of Psychology, Department of Teaching and Learning, Freiburg im Breisgau, Baden-Württemberg, Germany

Abstract

Gender stereotypes prevalent in society are considered an important explanation for gender differences and their influence on learners' scientific self-concept, interests and emotions. To avoid undesired effects of stereotypical perceptions on learning in the classroom, pedagogical agents (PA) with a gender-neutral design can be used. Two studies were conducted to examine the effects of gender-neutral PAs on student learning characteristics. The first study examined secondary students' perceptions (N = 128) of an ideal PA of a multimedia environment for science education. To examine effects of different agent features, we developed nine comic-based pedagogical agents that differ in gender (female, male, gender-neutral), age (young, old), fiction (real, fiction) and human-likeness (human, human-like, non-human). Its purpose was to investigate the popularity, acceptance and perceived emotions related to the presented educational offer. To identify possible predictors of the selection of PAs, in addition to gender and age, students' emotions were assessed. In the second study, two pedagogical agents, "Kogni", a gender-neutral looking superhero, and "MetaRob", a non-human robot, were selected for embedding in a multimedia webcomic based on the results of the first study. We assumed that a gender-neutral looking PA as a superhero and a non-human agent (robot) would invalidate the masculinely charged subject of physics and empower both male and female students in their science self-concept. To investigate these assumptions, 73 students participated in Study 2 in which they were guided in a webcomic about floating and sinking through the two selected PAs. A significant increase of science self-concept from pre- to posttest was found with a medium effect regardless of students' gender. Thus, independent of the usual classroom and regular instruction, the design of digital media offers the possibility of creating an (inclusive) learning environment that can reduce these stereotypes and can make students feel empowered in their science self-concept.

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503 Portrait of a STEM Identity: Exploring High School Student Classroom Experiences That Support Identity and Belonging in STEM

Elizabeth Saville

UBC Okanagan, Kelowna, BC, Canada

Abstract

This study examines how high school students understand their experiences in Science, Technology, Engineering and Mathematics (STEM) classrooms to have supported their identity construction in STEM. A qualitative portraiture methodology captures diverse stories of student sense-making in STEM classrooms which bring to life thematic findings of how high school students experience STEM classrooms in ways that support perceptions of belonging and identity in STEM. The portraits developed through this research may be useful for educators to build important knowledge about how students construct identities in STEM in and through their experiences in STEM classrooms and reveal broad equity-based supports for those participating in STEM that can be practically applied by educators as they work to create more equitable cultures of learning in their classrooms and decolonize practices and discourses in STEM education.

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869 Identity Construction Through STEM Education in a Postsecondary Context

Nurul Hassan Mohammad

University of Toronto, Toronto, Ontario, Canada

Abstract

Science, technology, engineering, and mathematics (STEM) education has emerged as a dominant educational discourse across all levels of education. As an academic discipline, postsecondary STEM education provides a richly complex and diverse environment for learning and identity construction, which go hand in hand: identity construction involves learning, and "learning implies becoming a different person" (Lave & Wenger, 1991, p. 53). Identity construction is a dynamic process deeply embedded in one's social, cultural, and political contexts and evolves through a dialectical relationship between structure and agency. I report the findings of this longitudinal ethnographic case study, where I utilized critical, poststructural, and sociocultural perspectives to inquire into this complex phenomenon of identity construction and generate an understanding of how STEM education shapes students' identities, specifically in a community college context. The findings of this research suggest that research undertaken from critical, postmodern and sociocultural perspectives enables us to gain a more nuanced understanding of identities. This research supports previous research undertaken by taking these aspects into account, and it points to further research dimensions of how our identities are constructed through power-laden processes that are mediated through both institutional configurations and our everyday practices (Foucault, 1997). Results also suggest that it will be important to explore the concept of achieving expertise in STEM skills and consider alternative structures that facilitate improvisation in a STEM context.

Virtual Parallel Session - 2.5 (Oral Presentations)

15:00 - 16:30 Friday, 1st September, 2023

Chair: Frederick Talaue

17 The "Factory of Ideas for Natural Science" Project: A Teaching Innovation Proposal to Address Energy with Future Teachers

Beatriz García Fernández[1], Christel Balck[2], Wim Temmerman[2]

[1]Faculty of Education of Ciudad Real. Science Education. Department of Pedagogy. University of Castilla-La Mancha, Ciudad Real, Spain. [2]Odisee University. Faculty of Education, Sint-Niklaas, Belgium

Abstract

Energy is a concept described in scientific literature as difficult to teach and learn. In this work a proposal to teach energy in teacher education is presented. The design and the implementation of this approach was framed in the "Factory of Ideas for Natural Science" project, granted by the Odisee University (Belgium). The didactic proposal was based on experimentation, dialogue and guided instruction, and focused on the capacity of transformation of energy. The didactic proposal was implemented at the University of Castilla-La Mancha (Spain) with 26 pre-service teachers of primary education in their last year of their training. The results revealed the didactic approach as useful to improve the understanding of the concept of energy, although they also reveal some shortcomings that aim to improve the teaching sequence. Some limitations of the intervention have also been discussed.

74 Analysis of Pre-Service Science Teachers' Perceptions about their Teaching Competencies

Cristina García-Ruiz, Teresa Lupión-Cobos

University of Málaga, Málaga, Spain

Abstract

In pre-service teaching, educational research on teacher identity contributes to understanding teacher learning and development, exploring the process's interconnections and socio-cultural nature. In this sense, the inquiry facilitates the pre-service teachers' identity development since it favours reflective learning and professional practice processes. Therefore, to provide tools for improving professional teacher development, this work presents a sequence of activities using a SWOT matrix to identify and reflect on the level of competence acquired by Physics and Chemistry pre-service teachers. The subsequent analysis of the results offers a broad vision of the perception of the actual grade of professional development accomplished within the

Master's Degree in Secondary Education Teaching.

81 How do Undergraduates Studying Early Childhood Education Plan Investigative Designs? Study of a Training Proposal

Yolanda Golías Pérez, Susana García Barros, Juan Carlos Rivadulla López, María Jesús Fuentes Silveira, Óscar González Iglesias

Universidade da Coruña, A Coruña, Galicia, Spain

Abstract

This work analyses the influence, on early childhood education undergraduate teachers, of a training proposal that is aimed at, among other aspects, their designing of investigative activities which use water as the subject matter. A design-based research methodology is being used. Following this methodology, the training proposal was put into practice over two consecutive academic years, and it was modified in the second year, based on the data obtained in the first. 256 students participated, forming 33 small groups in the first year and 28 in the second. The designs of the investigative activities, as proposed by the participants and aimed at children aged from five to six, were analysed using an analysis dossier. This included the investigation phases (exposition of the problem, proposed hypothesis, data gathering and analysis, and conclusions) and the level of teaching direction considered. The results show that in the first year, the designed activities were of an acceptable average quality and they even showed improvement after their remodelling for the second year. However, there were noticeable deficiencies regarding the consideration of the conclusion stage of the investigation and the specification of the teaching direction. Based on the foregoing, suggestions are provided for a remodelling for a subsequent academic year.

1199 Participating in Translanguaging Spaces in Science Learning Multimedia for Children From Low-Income Communities

Frederick Talaue, Raymund Sison, Kristine Hernandez, Allen Mateo Muñoz, Ryan Samuel Dimaunahan, Auxencia Limjap, Angelica Joy San Buenaventura

De La Salle University, Manila, Philippines

Abstract

Research on making science learning more accessible to young learners also learning English as an additional language has re-emerged in recent years. In the teeth of the Covid pandemic, Filipino multilingual learners were forced to study using English-medium self-learning materials at home. In our view, this only furthered linguistic marginalisation among learners from low-income communities who typically perform poorly in reading proficiency tests. Studies have documented how translanguaging science classrooms help support students' language and socio-emotional development. This paper argues that deepening engagement with science ideas and practices must also involve representing translanguaging pedagogy in curriculum materials. As part of a larger research project that developed curricula for delivery via

datacasting technology, the present study developed translanguaging science multimedia resources. Thirteen Grade 6 students from a public elementary school participated in our year-long datacasting simulation. Participants engaged with learning materials individually at home using the phone tablets we provided. Using various data sources, including student artefacts, online feedback surveys, online focus group discussions, and individual interviews, we explored how learners participate in a virtual multimodal science learning space using a cultural-historical activity theory lens. The science curriculum framework primarily focused on the science practice of constructing explanations and was informed by ways of linking to learners' everyday practices and identities. Our findings suggest that while learning participation increased and appropriation of disciplinary sensemaking gradually improved, other extracurricular practices are necessary to support productive language trajectories in this new virtual learning environment.

Virtual Parallel Session - 2.6 (Oral Presentations)

15:00 - 16:30 Friday, 1st September, 2023

Chair: Marina Constantinou

1124 What Can We Expect From Teacher Training to Boost Science-Health-Environment Literacy?

Olga Mayoral, Nuria Álvaro, Valentín Gavidia

University of Valencia, Valencia, Valencia, Spain

Abstract

Transfer in education can be seen as a multi-level chain reaction. From the university level we can influence the first level through both initial and ongoing teacher training. The next level concerns the influence of teachers on their students, followed by a desired transgenerational impact on their families and on the whole educational community. Regardless of the expectations of the programmes and the goodwill of teacher trainers, the evaluation and analysis of the effectiveness of the transfer process is considered essential to ensure the success of the effort and advisable to modulate the educational proposals, modify the teaching guides or official curricula, introduce new teaching methodologies, etc. In this paper we present the transfer of Environmental Health issues in the context of an in-service training course for secondary school teachers. The teacher assessment instruments consisted of forum activities, assignments and questionnaires carried out on an ongoing basis. In order to assess the learning progress of the participants, some instruments were applied several times as a pre- and post-test and analysed quantitatively and/or qualitatively. The results obtained have shown that the participants, at the end of the course, have a greater understanding of the complexity of environmental health and have shown how to apply them in the adaptation of the didactic material provided and in the creation of new competence proposals in EH. On the other hand,

teachers have continued to show difficulties in fully understanding the concept of environmental health, in its more open and comprehensive version, and in the correct application of the Knowing how to be of the EH competence.

1250 The Perspectives of Natural Science Teaching in Supra Curricula

Mauritz de Vries, Cristiano Mattos

Universidade de São Paulo, São Paulo, SP, Brazil

Abstract

In the last 20 years, several countries carried out curricular reforms in basic education, centralized at the federal level and based on the concept of competencies. These reforms have impacted educational trends for teaching Natural Sciences. Such changes have promoted an international standardization of teaching and learning, following a globalization trend that also affects education. This standardizations have been mediated by international evaluation tests (e.g., the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMMS), the emphasis on education as a promoter of economic growth, the information and communication technologies and, strongly, for the support and action of intergovernmental agencies and supranational organizations such as the Organization for Economic Cooperation and Development, Organization of United Nations Educational, Scientific and Cultural Organization, World Bank and the European Parliament (Stacey et al, 2018). Given this scenario, we seek to understand the trends for teaching natural sciences driven by recent supra curriculas produced by transnational agencies. The supra curricula analyzed have been developed to give substance to a school that trains citizens capable of adapting to a world progressively globalized, complex, competitive, challenging to predict, and that lives with problems related to crises economic, political polarization, social inequality and socio-environmental impacts of modes of production and consumption. They present criticisms of the transmissive methodologies of the traditional school with a propaedeutic character and, thus, encourage students to work with significant socio-environmental contexts through active methodologies. The students and citizens to be trained are equipped to solve problems and participate in citizenship, but these supra curricula do not delve into the criticality and political role that students can develop to overcome the structural contradictions of society's production and consumption practices. The natural sciences are presented as a key area to achieve the proposed objectives in the 21st-century.

343 Plant and Animal Photographs in the Science and Environment Textbooks of the Greek Primary School

Georgios Ampatzidis[1], Alexandros Amprazis[2], Penelope Papadopoulou[2]

[1]University of Thessaly, Volos, Greece. [2]University of Western Macedonia, Florina, Greece

Abstract

Humans' connectedness to nature has always been a matter of discussion and sometimes has been considered as one of the main environmental degradation causes. Within this framework, there has been a focus on people's interaction with plants and especially on a phenomenon called plant blindness. Research shows that plants do not seem to have a strong presence in students' everyday life and a general zoo chauvinism seems to be established in educational institutions to the detriment of botanical education. Aim of this research was to examine the presence of plants in the photographs included in the Greek primary school science and environment textbooks. We investigated six textbooks and we identified 948 photographs in total which we coded in mutually exclusive categories. Our results showed that humans were the most frequent subjects of the photographs of the textbooks we looked at; among humans, plants and animals, plants were the least popular. We discuss our results in the light of the relevant literature.

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498 Making It work:Practical Work in Higher Life Sciences Education

Marina Constantinou[1], Nikolaos Fotou[2]

[1]University of Lincoln, Lincoln, Lincolnshire, United Kingdom. [2]University of Lincoln, Lincoln, lincolnshire, United Kingdom

Abstract

Practical work has been regarded as an essential part of science education across all levels of education. Especially in higher education, the studying of science devoid of practical work has been virtually unimaginable. The unquestionable, as argued in this paper, idea is that practical work is an effective teaching method while also having an affective value. Empirical evidence on such a claimed effectiveness is scarce across science degrees, however, and to a greater extent in the field of Life Sciences. This paper reports on a mixed-methods case study conducted at a British university examining the effectiveness of practical work in promoting conceptual understanding, skill development as well as having an affective effect. Questionnaire responses regarding experiences and expectations of undergraduates in the laboratory before the beginning of the academic year and at the end of the semester were used in assessing the effect of practical in the cognitive, psychomotor, and affective domain. These were combined with laboratory observations and in-situ informal assessment of undergraduates' understanding, and skill development in further empirically assessing whether practical work can enable students' meaningful learning and if so how. Findings revealed effectiveness of practical work in the development of manipulative skills and in some of the domains, namely active engagement within the psychomotor domain and positive beliefs towards experiences in the affective domain. This effectiveness was observed when lessons had a certain structure and clearly set aims. Development of conceptual understanding was lacking whilst it was found that undergraduates do hold an expectation more cognitive engagement in the laboratory. This paper points to the need for directed and guided instruction during practical work and explication of objectives and overall aims.

Virtual Parallel Session - 2.7 (Oral Presentations)

15:00 - 16:30 Friday, 1st September, 2023

Chair: Frackson Mumba

792 An Investigation Into Pre-Service Science Teachers Understanding of Nature of Science Using a PCK Lens

Louise Lehane

St Angela's College, Sligo, Ireland

Abstract

This study examined pre-service science teachers' knowledge of Nature of Science (NOS) using a Pedagogical Content Knowledge (PCK) lens. A particular NOS conceptualization, the Family Resemblance Approach (FRA) was employed to conceptualize and analysis pre-service teachers' knowledge of NOS. The findings showed that their knowledge of components of NOS were lacking. This indicates that the pre-service teachers' apprenticeship of observation as students does not include experiences of NOS and therefore need to be supported in developing this component of their PCK.

220 Learning the Greenhouse Effect with Computer Models – Influences on Knowledge and Attitudes

Hanin Safadi Darawshe, Elon Langbehiem

Ben Gurion University, Beer Sheva, Negev, Israel

Abstract

Manmade emissions of greenhouse gases into the earth's atmosphere trap infrared radiation that warms the planet, and contributes to climate change. In order to equip students with knowledge and skills to understand and address the greenhouse effect, teachers often use computational models. In this study, we examine the consequences of introducing computational models on students' cognitive load, conceptual understanding and environmental attitudes. In this study we compared three groups of 11th graders: one learned about the greenhouse effect mechanism with a macro-level computer simulation, another group used a molecular-level model of the interaction between radiation and the greenhouse gases, and a control group learned the topic without any simulation. We assessed student understanding, cognitive load and attitudes towards climate change before and after instruction. Our data shows that the molecular-level group exhibited the highest learning gains, although they reported higher cognitive load than the macro-only group. However, in terms of attitudes towards the phenomenon, the control group exhibited the largest pre to post

changes.

882 Multimodality in Pre-Service Chemistry Teachers and Integrating Project in Textbooks

Eduarda Giese, Nicole Glock Maceno

UDESC, Joinville, Santa Catarina, Brazil

Abstract

This work analyzes how four undergraduate students in Chemistry of the sixth phase of a public University of Santa Catarina identified and understood the semiotic modes in an integrative project of a textbook of Natural Sciences and its Technologies, related to the ocean theme. Twenty-eight questions were asked in an online form, answered and analyzed from the theoretical study of multimodality. The objective of the study focused on the exercise of multimodal identification and on the views of undergraduates about the ocean in an initial training context. The responses produced were inductively coded and classified into the categories: Views on the ocean, Semiotic modes and Thematic approach. Variations and divergences were found in the classification of certain semiotic modes in didactic work. The undergraduates confirmed the multimodal nature of communication and representation in Science integration project, however, it was noticeable the need for discussions about the relevance of multimodality, the differentiation of types of semiotic modes, in addition to critical thinking for the understanding and approach of the ocean theme.

1185 Inquiry Representation in Science Practitioner Journals for Teachers

Frackson Mumba[1], Laura Pottmeyer[2], Alexis Rutt[3]

[1]University of Virginia, Charlottesville, VA, USA. [2]Carnegie Mellon University, Pittsburgh, PA, USA [3]University Of Mary Washington, Fredericksburg, VA, USA

Abstract

This is part of a larger study that is examining inquiry representation in the articles published in Science Practitioner journals for teachers. These articles are written by teachers, and scientists. It is assumed these articles might provide a window into the type of inquiry instruction the authors tend to emphasize. The analysis is still going on. In this proposal, we have reported the results from the analysis of one of the Science Practitioner journals- *The American Biology Teacher*. Other results will be presented in the presentation. The nature of inquiry representation in the articles is being determined by establishing the extent to which six essential features of inquiry-Question, Evidence, Analysis, Explain, Connect and Communicate- are addressed in the articles. Most essential features of inquiry were adequately represented in the articles we have analyzed so far. However, most science activities did not have investigative questions to guide inquiry process. There is more partial inquiry than full inquiry representation in the articles analyzed. Detailed results and Implications will be discussed.

Virtual Parallel Session - 2.8 (Oral Presentations)

15:00 - 16:30 Friday, 1st September, 2023

Chair: Mwenda Kudumu

875 Intercultural Dialogue Between Scientific Knowledge and Biblical Knowledge: Analysis of Excerpts From a Didactic Sequence

Ana Caroline Maia Barboza[1,2], Emanuele Maria Leite Suzart[1,2], Geilsa Baptista[2], William Cobern[3]

[1]Universidade Federal da Bahia, Salvador, Bahia, Brazil. [2]Universidade Estadual de Feira de Santana, Feira de Santana, Bahia, Brazil. [3]Western Michigan University, Kalamazoo, Michigan, USA

Abstract

The present work presents the partial results of an investigation carried out with the objective of analyzing excerpts from a didactic sequence (DS) in order to perceive signs of openness to the intercultural dialogue between scientific and biblical knowledge. The data were analyzed and categorized and it was possible to perceive that the participant proposes moments of dialogue, however, it is not clear how it will be conducted.

497 Situated Cognition and Dialogue of Knowledge: Contributions to Reverse Logistics Into Brazilian Schools

Jorge Arnaldo Troche Escobar[1], Helenadja Santos Mota[2], Geilsa Costa Santos Baptista[3]

[1]Universidade Federal da Bahia, Salvador, Bahia, Brazil. [2]Instituto Federal Baiano, Valença, Bahia, Brazil. [3]Universidade Estadual de Feira de Santana, Feira de Santana, Bahia, Brazil

Abstract

This work aims to explore how situated cognition based on dialogue between cultural knowledge can help people understand the importance of reverse logistics into Brazilian schools contributing to its implementation. For this, we carried out a theoretical review of literature in the field of science teaching, environmental education and production engineering. Our results indicate that it is necessary to involve the subjects in direct contexts and situations in which they experience concepts and actions regarding school waste. Environmental education with reverse logistics will develop individuals involved with actions not only in schools but also into their families and communities. The process of understanding reverse logistics needs the support of dialogue between cultural knowledge in the negotiation of interests to promote the recycling and reuse of discarded products. The dialogue generates communication of several ideas and knowledge that will support reflections on the importance

of separating and collecting different types of waste, which can be recycled, thus being reused in new products through reverse logistics.

208 Physics Education Research: Moving From Assessment of Learning to Assessment as Learning

Feral Ogan-Bekiroglu

Marmara University, Istanbul, Turkey

Abstract

The purpose of this review paper is to explore the relationship between physics learning and assessment by evaluating how assessment is implemented in physics education. Therefore, recent studies were reviewed and their results were analyzed to gain better understanding of the nature of the relation between assessment and physics learning. Reviewing of physics education research shows that the researchers preferred to implement concept maps for the purpose of summative assessment. There is a tendency in the studies that performance assessment and portfolio are implemented for the purpose of assessment for learning. Yet, feedback was not provided enough to the learners in most of these studies. In addition, assessment methods were not used in any of the studies above for the purpose of assessment as learning. The relation between physics learning and assessment is mostly built on assessment of learning where students are assessed after the instruction and providing feedback is not a priority. This study suggests that assessment as learning needs to be the purpose in physics education and research examining how assessment is utilized as a tool for helping physics students perform self-assessment and self-regulate their own learning with reflection and critical analysis is needed.

370 Practicing Culturally Relevant Education in Science Centers

Mwenda Kudumu

North Carolina State University, Raleigh, North Carolina, USA

Abstract

The discourse in peer-reviewed literature between 2015 and 2020 on diversity, equity, and inclusion (DEI) in informal science education (ISE) institutions revolved closely around broadening the participation of communities of color. Culturally Relevant Education (CRE) has evolved to address these issues across formal education content areas. CRE describes educational opportunities designed with the whole person in mind that consider and preserve the culture and experiences of the learner while maintaining high levels of academic excellence and advanced skill transfer. Although very few research studies on CRE investigated ISE institutions, CRE has been useful in formal science settings and has potential usefulness in ISE settings. A pool of informal educators from science centers located within the USA was identified using snowball sampling. Twenty-two individuals representing a mixture of

experience level, type and size of organization, race and ethnicity, gender, and organizational commitment to DEI agreed to participate in the study. Participants completed a self-administered survey providing demographical information about themselves and their organization. Semi-structured interviews were conducted with questions based on constructs from the CRE framework. The data analysis processes followed standard qualitative techniques involving several stages of open, a priori, categorical, and emergent coding. By examining how SCE practice CRE in science centers this study supports the development of a culturally relevant model that is applicable to informal science education settings. Findings from this basic qualitative research study revealed SCEs' practices of cultural relevancy in learning and teaching science in informal environments. The study identified current, ideal, and supportive practices as well as barriers to applying culturally relevant principles in ISE institutions. SCEs described current practices that were educator-focused, institutional initiatives, and societally driven. Participants also envisioned ideal supportive practices including DEI hiring, centering CRE, and CRE-related training. Additionally, participants highlighted practices that acted as a barrier to enacting CRE.

Virtual Parallel Session - 2.9 (Oral Presentations)

15:00 - 16:30 Friday, 1st September, 2023

202 Sustainability and Climate Change in Eco-Schools: A Case Study

Sevinç Gelmez Burakgazi[1], Michael Reiss[2]

[1]Hacettepe University, Ankara, Turkey. [2]University College of London, London, United Kingdom

Abstract

Sustainability, which is a priority, depends on the interrelationships between three pillars (environmental, social, economic) which affect each other. However, it remains less clear how critical stakeholders in education perceive the concept of sustainability and act accordingly. In order to gain new insights, this research scrutinizes perceptions on sustainability and climate change in two eco-schools in England for primary children. Through a qualitative case study design, we undertook interviews with teachers and headteachers, focus groups with fourth and fifth year students, and in-class observations, and analysed these along with student notebooks and photographs of school grounds to understand participants' self-reported knowledge and perceptions of sustainability and climate change. The results showed that the integration of sustainability in the curriculum was limited and problematic despite the fact that all students were aware of the environmental dimension of sustainability, like climate change and the overuse of natural sources. There is a need for primary schools to enable and motivate adults to enable richer teaching about sustainability and climate change.

1281 Integrating Climate Change in Secondary School Science Instruction: The Case of Spain

Silvia Alcaraz-Dominguez, Mario Barajas

Universitat de Barcelona, Barcelona, Spain

Abstract

This paper reports on a qualitative investigation aiming to bridging the gap between climate change education policy and practice in Spain. Although recent reforms stress the importance of formal education in shifting towards a more climate friendly economy, climate change is only anecdotally represented in Spanish educational policy, which makes it difficult for teachers to integrate it in their practice. On this basis, two parallel focus groups were carried out with 29 experts, researchers and practitioners interested in climate change education, aiming to 1) Analyse current educational policies and practices regarding the teaching of climate change in secondary education in Spain, 2) Exchange views on teacher training and support in relation to climate change; and 3) Discuss the teaching of climate change in the science classroom. Results showed that climate change education is not sufficiently developed in the Spanish curriculum, but teachers have a degree of freedom that would allow them to introduce climate issues without major obstacles. Further, climate issues to bring to class were identified, including forest fires and different aspects of the food supply chain. The most appropriate methods to teach climate change issues in secondary school were found to be Inquiry-Based Learning and Project-Based learning. These results contribute to clarifying how climate education should unfold in this specific sociocultural context, providing access points to policy makers, curriculum developers or teacher training providers, among others.

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427 Fostering Students' Action Competence to Preserve Insect Biodiversity

Peter Lampert, Daniel Olsson, Niklas Gericke

Karlstad University, Karlstad, Sweden

Abstract

Insect decline is a highly relevant environmental issue and scientists call for educating the public to take actions to preserve insect biodiversity. Science education can play a significant role to answer this call, but there is little educational research on teaching interventions and their effect on students' competences. Therefore, the presented educational design research project focuses on designing, evaluating, and adapting a theory based teaching intervention aiming to foster learners' action competence to help insects. As part of this intervention, students plan and take personal actions to support insects at home and engage in observing insects as citizen scientists. More than 200 students from grade 7 (age 13-14) from a Swedish municipality took part in the intervention in 2022 during their science lessons. Both quantitative and qualitative data were collected to assess the impacts of the intervention on students' competences and attitudes towards insects in a pre-post design. The results indicate that the intervention led to more positive attitudes towards insects and that it widened students' knowledge about actions

to support insects. The quantitative assessment shows that students' self-perceived knowledge, confidence, and willingness to take actions increased significantly during the intervention. The feedback from students and teachers regarding the teaching materials indicate a good fit of the intervention. In summary, the presented project provides a promising way for educating about insect decline and ways to preserve insect biodiversity in a wide range of educational settings and age groups.

Virtual Parallel Session - 2.10 (SYMPOSIUM)

15:00 - 16:30 Friday, 1st September, 2023

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63 Communities of Practice and Teacher Professional Development: Experiences from Colombia, Brazil and Luxembourg

Chair

Christina Siry

Discussant

Isabel Martins

Abstract

Most of the time, when Teacher Professional Development (TPD) is addressed, it relates to the process of a teacher attending course offerings linked to their own subject, or more overarching trainings within education (such as about planning or assessing), often in order to meet mandatory hours to comply with education acts on teacher continuous education. Researchers from Colombia, Brazil and Luxembourg come together in this symposium to present their experiences within Teacher Professional Education in their countries, highlighting the possibilities of co-teaching and cogenerative dialogues (Tobin, 2006; Tobin & Roth, 2005) and the dimensions of communities of practice (being mutual engagement, joint enterprise, and shared repertoire – Wenger, 1998/2005), while presenting the aspects of their own school-university partnerships. These partnerships uncover a heterogeneity of members of these communities of practice, that includes researchers, teacher educators, and teachers (students also take active part within some communities). Grounded on sociocultural perspectives, a diversity of horizontal methodologies is used, and each research present its set of data by revealing the intention to be responsive to societal needs, including socio-scientific issues that, bringing together. Anchored on structures of diverse collaboration, each study brings to light processes of negotiation and power relations, whereas organizational cultures of the spaces emerge and partnerships are grounded on ongoing open dialogue and trusting relationships.

959 Examining a School-University Partnership to Support Elementary Science Education in an European Country

Maiza Trigo, Kerstin te Heesen, Sara Wilmes, Ragnhild Barbu, Christina Siry

University of Luxembourg, Esch-sur-Alzette, Luxembourg

Abstract

This contribution explores a school-university partnership that has supported in-service primary teachers to engage with science education in ways that are responsive to challenges faced by teachers and students in a European country. The [blinded] Center is the space where researchers and elementary teachers come together, as a community of practice, to engage in cogenerative dialogue in order to address elementary science professional development in a European country. Using a participatory research process and interpretive analytic lens, data from research conducted within the [blinded] Center's projects (video recordings, researchers' notes and reflection pieces) narrate the story of this school-university partnership, unpacking the multilayered building of communities of practice, possibilities of shifting toward open-ended teaching approaches in line with the competency-based approach supported by the An European country national curriculum, and reflection pieces on the tensions arising from the multilingual changing context. Findings reveal the team's work dynamics to support inquiry-based elementary science education is grounded on a structure of collaboration, built upon a process of reflect-dialogue-act (co-teaching included) and which, as examined, can provide recommendations to support sustainable partnerships based on ongoing open dialogue and trusting relationships.

1002 Science Teachers' Education in a Community of Practice - the Approach of "Energy and Matter" as a Socioscientific Issue

Rita Prata[1], Anderson Marinho[2], Edgar Miranda[2]

[1]Universidade Federal do Rio de Janeiro, Rio de Janeiro, Rio de Janeiro, Brazil. [2]Colégio Pedro II, Rio de Janeiro, Rio de Janeiro, Brazil

Abstract

This text presents the analysis of a teachers' education experience for the work with socioscientific issues in the context of a community of practice (CoP). The CoP is formed by in-service and, pre-service biology teachers, researchers in science education, biology and physics and seeks to collectively produce pedagogical knowledge about emerging socio-environmental problems. In the analysis, the organizational aspects of the CoP were considered, as well as the science contents employed in relation to societal and environmental issues. The results suggests that the work in CoP contributes to the construction of a broader representation of complex and socially relevant topics by all their members, providing a powerful and interesting platform to build science teachers education based on SSI.

1012 Design of a proposal with elements of co-teaching in socio-cultural approaches: contributions of the history and philosophy of experimental activity in hydraulics.

Helga Almeida[1], Edwin García[2]

[1]Universidad del Valle, Cali, Valle del Cauca, Colombia. [2]Universidad del valle, Cali, Valle del Cauca, Colombia

Abstract

The present paper highlights elements of the co-teaching model implemented in a Colombian educational institution through a proposal designed for the teaching of the sciences, specifically hydraulics, from cultural perspectives where the problems of the environment are recognized, the role of experimental activity, the use of instruments to measure the movement of water and formalization processes. This model is based on the understanding of teaching as a socio-cultural historical activity in which teachers collaborate to create a supportive environment (Roth & Robin, 2005). Thus, experiences are built in schools where teachers in the regular classroom and the research teacher work collaboratively, linking the school and the university through solutions to problem situations to encourage discussions to evaluate alternatives, discuss decisions and plan interventions. Therefore, the semi-structured interview technique is linked to analyze the responses obtained, the impact of the explanations and a critical historical analysis of hydraulics. This perspective allows us to address the progress of students more efficiently by having the collaboration of the other professionals involved, since the identification of problems associated with the teaching of physics allows us to reflect on the contents that are taught in a traditional way, and which leave out enriching contributions of phenomenology. In the case of hydraulics, teaching has been limited to topics such as fluids, pressure, continuity equation and Bernoulli's principle, which are taught through processes of memorization and application of algorithms ignoring their impact on daily life, because situations such as the analysis of rivers, operation of the drains, irrigation channels and generally current problems do not arise.

Virtual Parallel Session - 3.1 (Oral Presentations)

17:00 - 18:30 Friday, 1st September, 2023

Chair: Ihsan Ghazal

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554 Visual Literacy Competence in Science Education: Teaching Innovative Actions to Train Better Teachers

Esther Paños[1,2], Beatriz García Fernández[3,2], José Reyes Ruiz-Gallardo[1,2]

[1]University of Castilla-La Mancha, Albacete, Castilla-La Mancha, Spain. [2]Botanic Institute. University of Castilla-La Mancha, Albacete, Castilla-La Mancha, Spain. [3]University of Castilla-La Mancha, Ciudad Real, Castilla-La Mancha, Spain

Abstract

This work presents the actions carried out in the frame of the "Promoting the development of Visual Literacy in Science Education in future early childhood and primary teachers" teaching innovation project (University of Castilla-La Mancha). The two main objectives were: a) the diagnosis of the level of visual literacy competence associated to science contents in future teachers, and b), the development of actions aimed at improving teacher training along the lines suggested by the initial diagnosis. The actions performed in the classroom focused on the drawing of anatomy cross-sections, the visualization of a 3D virtual anatomy model, the construction of a physical anatomy model and the guided observation of a different one by answering questions. The main results point to a lack of visual literacy competence associated with anatomy content in the future teachers who joined the project, and limited experience with different ways of representing the human body. The shortcomings found in the teachers are similar to those found in the children, which is of particular concern. The effectiveness of the teaching innovation actions was partially assessed, but the construction of a physical anatomy model resulted in better outcomes than the mere observation of a virtual one.

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725 Serious Games: Chemistry Teachers' Views on Their Role in Theaching and Assessment of Acquisition of Chemical Concepts

Joaquim Fernando Mendes da Silva, Rodrigo Jose Santana Ziltener

Federal University of Rio de Janeiro, Rio de Janeiro, RJ, Brazil

Abstract

The pedagogical applications of serious games for promoting Science learning have increased steadily in the last decade, as indicated by the number of research publications found in Web of Science and Scopus. Their use in classes promote the improvement of skills, memorization and holistic comprehension of scientific concepts, having also a positive effect on the motivation of the students. In this communication we explored through a qualitative methodology how a group of eight Chemistry teachers working in public and private schools

in Brazil have been using serious games in their classes, as well as how their pre-service and in-service formation influence their skills in using these games. The results show that few of them have been using serious games, which were used mostly as motivational tools and to enhance memorization of concepts. The reduced pedagogical use of serious games can be related to a deficiency in their pre-service formation in building innovative professional skills.

1064 Leadership Perspectives on Impacts and Outcomes on Relationships Between Schools and Local STEM Centres

George Aranda, Linda Hobbs, Peta White, Seamus Delaney, John Cripps Clark

Deakin University, Melbourne, Victoria, Australia

Abstract

Interest in the STEM curriculum, skills and capabilities has seen an increase in the development of relationships between schools and local STEM centres. The Victorian Tech Schools Initiative aims to work with schools to provide young people with STEM skills for future employment in local industry growth sectors. Drawing on findings from our evaluation of this Initiative, this paper explores the question: What are the impacts and outcomes of school engagement with local Tech Schools? Interview data with school leadership and teachers whose schools have used Tech School facilities were analysed. Thematic analysis identified five ways that characterised outcomes and impact of their relationships between STEM centres and schools: the impact of school leadership on the positive relationship with the Tech School; Tech Schools catering for the needs of schools; closer relationships between staff at the Tech School and the schools; the impact that Tech Schools had on schools' curriculum, and the perceived relevance of local-based STEM centres such as the Tech School to students and staff; and clear identification of areas that could be enhanced in future. The values that are placed on these interactions by leadership are summarised, as well as critiques that arose. Evidence shows that leadership value the unique collaborative partnership between Tech Schools and schools that enhance school curriculum and ensure that programs are relevant to school needs. Leadership are starting to include the Tech School in their school's strategic planning and Tech Schools are increasingly seen as part of their normal business.

209 A Learning Progression on Lebanese Students' Systems Thinking about the Immune System

Ihsan Ghazal, Hayat Hokayem

Texas Christian University, Fort Worth, Texas, USA

Abstract

Research suggests that students hold misconceptions about the immune system, but little is known about how they reason about the mechanism by which the immune system operates. This study adopts a systems thinking framework to identify students' reasoning about the immune system and develop a Learning Progression (LP) using data from Grades 8 and 12

students. We used longitudinal data to examine how reasoning developed for the same Grade 8 students later in Grade 12 in Beirut, Lebanon. Participants included 46 Grade 8 students, and we followed 16 of them through Grade 12 while studying an immunology unit. Data analysis involved Grade 8 and 12 students' responses during a pre-/post-assessment test, Grade 8 responses on activity worksheets, and Grade 12 responses to post-unit interviews. We revised a previous LP using additional Grade 8 data and identified two extra lower reasoning levels. These levels included explaining causal relations between events without recognizing any mechanism and identifying a process using incorrect scientific terms. We also tracked one student's reasoning from Grades 8 and 12, who showed difficulty linking specific to non-specific immune responses.

Virtual Parallel Session - 3.2 (Oral Presentations)

17:00 - 18:30 Friday, 1st September, 2023

Chair: Daniela Schriebl

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205 Teachers' Views on the Development of Zero Waste Education Within the Scope of Sustainable Development Goals

İlkem Özdinç[1], Serhat Altıntaş[2], Gaye D. Ceyhan[1]

[1]Boğaziçi University, İstanbul, Turkey. [2]İstanbul University-Cerrahpaşa, İstanbul, Turkey

Abstract

Zero Waste Project aims at individuals to gain environmentally friendly consumption habits and to raise awareness about waste management to ensure sustainable development. The current study aims to determine the teachers' views about developing a Zero Waste Education. This qualitative research was carried out with 20 teachers from different disciplines, including native language, mathematics, science, and social studies. The data was collected in the 2022-2023 academic year. The results revealed that teachers have limited knowledge about sustainable development and zero waste. For this reason, while all teachers agreed on providing education on sustainable development and zero waste, they emphasized the importance of implementing this education as a separate course and using new methods not only for students and teachers but also for parents. It is expected that the results obtained from this research will create an opportunity for the preparation of zero-waste education within the scope of sustainable development purposes.

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436 Self Perception of the Importance of Actions to Fight Climate Change in Primary School Children

Enzo Ferrari[1], Vanessa Ortega-Quevedo[2], María Antonia López-Luengo[2], Camilo Ruiz[1]

[1]EMC3 Research Group. Universidad de Salamanca, Salamanca, Spain. [2]F Educación de Segovia. Universidad de Valladolid, Segovia, Spain

Abstract

Climate Change is one of the most critical threats to all the species on earth. Students must learn the importance of this problem and develop competences in school to create effective mitigation and adaptation strategies. To achieve the necessary decarbonization in the short window of opportunity, it proposed the inclusion of Climate Change Competence (C3). This competence will provide Knowledge, Skills and Attitudes to all students in the formal educational systems to deal with this planetary crisis. The work presented here discusses how C3 is assessed using an adapted questionnaire and the results obtained from a Spanish group of 459 primary school students (11-12 years old). It also discussed the differences between girls and boys participants. Finally, it analyzed how they perceive their actions concerning Climate Change. Misconceptions of the effectiveness of our actions are a problem for change, and this phenomenon needs to be tackled in schools.

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177 Modelling Authenticity in Science Education

Daniela Schriebl[1,2], Andreas Müller[2], Nicolas Robin[1]

[1]St.Gallen University of Teacher Education, St.Gallen, Switzerland. [2]University of Geneva, Geneva, Switzerland

Abstract

Over the past few decades, the words ‘authenticity’ and ‘authentic’ have been employed more and more frequently in educational contexts. It is asserted that authenticity is a key notion in science education, among others for students' motivation and interest in science. However, as numerous authors have demonstrated, 'authenticity' is utilised, defined, and conceptualised in a variety of ambiguous ways and contains multiple dimensions. To date, there is no model that unifies and organises the multiple conceptualisations, definitions, and findings, as well as their educational implications. In this contribution, we provide a model that integrates a wide variety of previous authors' work in a cohesive manner, takes into consideration the model's multidimensionality, and explains each dimension with reference to prior work before integrating them into the overall model. The model is conceived as a tool for practitioners and researchers, and it is flexible enough for future extensions and refinements. We will present the model, present examples of applications for research and practice, and possible future extensions.

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732 A Carnival in Chemistry: Proposal and Application of a Didactic Sequence on Glitter as a Possibility of Re-Signification of Identities Based on Queer Theory

Caio Gentil Nascimento da Silva, Marcos André Ferreira de Araujo Santos, Joaquim Fernando Mendes da Silva

Federal University of Rio de Janeiro, Rio de Janeiro, RJ, Brazil

Abstract

Different subjectivities and identities are excluded from political participation and knowledge production due to the social scenario marked by male domination, which asserts its power based on a categorizing norm. Whether in the production of science or the school environment, interpersonal relationships reinforce the processes of marginalization of individuals who do not fit the canons of genders and sexualities. Concerning disrupting these dynamics, this paper presents the results of a didactic sequence on glitter and its contributions to the matter of the LGBTQIAP+ population and other social and environmental impacts. This didactic sequence was developed and applied between the interweaving of Chemistry Teaching and queer studies in order to promote a transgressive education based on social equity.

Virtual Parallel Session - 3.3 (Oral Presentations)

17:00 - 18:30 Friday, 1st September, 2023

Chair: Basak Helvaci Ozacar

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285 Science Track Attendees' and Non-Attendees' Science Experiences at Science Fiction Conventions

Gina Childers[1], Rebecca Hite[1], Kania Greer[2], Samanthia Noble[1], Christi Whitworth[1], Weverton Ataide Pinheiro[1], Joshua Cruz[1]

[1]Texas Tech University, Lubbock, TX, USA. [2]Georgia Southern University, Statesboro, GA, USA

Abstract

Science fiction conventions offer science tracks which explain the 'science behind the fiction.' This study explored attendees' interests in science fiction and science in two groups: individuals who attend and those who do not attend science track events. Using a semi-structured interview, the present study documented the 1) factors that contributed to the origin stories of these attendees and 2) how these individuals conceptualized connections between science fiction and science fact. Participants (N=12) shared that their exposure to science fiction and science originated during childhood (in their family, at school) as well as citing the importance of a sense of belonging at these events. Additionally, participants explained the association(s) between science fiction and science fact stating that science questions are often generated as

a result of what occurs in science fiction media and advocated for more science to be embedded in convention activities. Findings may aid researchers explore how informal science experiences at science fiction conventions connect to one's science identity and interest.

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854 Teaching Physics Concepts & Nature of Science Tenets During the Participation in a Robotics Competition

Anna Koumara, Hariton Polatoglou

Aristotle University of Thessaloniki, Thessaloniki, Greece

Abstract

20 High School students, working in 7 groups, prepared to participate in a National Robotics Competition. They needed to design and build their own robot, to perform specific tasks. We took this process to study how is it possible in parallel to teach physics concepts from mechanics, integrate nature of science tenets into the instruction and cultivate soft skills. Results are analyzed through discourse analysis, a nature of science questionnaire, a rubric that measures the soft skills development, and classroom observations. The study is in progress, but until now it can be pointed out that the groups that have progressed, have a better understanding of physics concepts, like inertia. Students are not aware of most of the nature of science tenets. Even though it is possible to include them in the sessions, students are not willing to listen, since their focus is on their preparation. We plan to retry in the aftermath of the competition. As for the soft skills, it is pointed out that the more they are involved in the project, the more they develop them.

1045 Towards Defining Success Factors for School Visits to Digital Science Centers

Andreas Göransson, Konrad Schönborn, Lena Tibell

Linköping University, Norrköping, Sweden

Abstract

School visits to science centers can provide valuable opportunities for pupils to engage with science content and practices different from the traditional classroom and raise pupils' interest in science and science careers. Teachers play a key role in the success of a visit by linking to classroom practice. Unfortunately, visits tend to be viewed as an isolated experience by teachers and pupils, wherein pre- and post-visit activities that actively integrate the visit into classroom practice are often lacking. While many science centers offer suggestions for such pre- and post-visit activities, teachers do not typically take advantage of them. Thus, it is imperative to explore teachers' views on successful visits and barriers that may influence the experience for pupils. As part of a larger research project on success factors for school visits to science centers, we examined teachers views on success factors, motivations and barriers to visiting a digital science center in Sweden. Based on interviews and the accompanying literature, a questionnaire was developed and distributed to teachers in local compulsory

schools. Responses from 50 teachers revealed that the most important success factors were a well-prepared program, that the content is conveyed visually, that the visit induces pupils' curiosity, and that the activities are linked to the curriculum. Teachers most common motives for visiting were that it offers a unique experience from the classroom, that the visit is free and that the program considers pupils' needs. The majority of the teachers conducted no or limited pre- and post-visit activities, although the science center offers lesson plans linked to the visit. Main obstacles to visits included public transport costs for suburban and rural area schools. Our results suggest that the design of a visit should also consider and support the practical constraints for teachers and schools.

1046 Public Computing as Third Space: Exploring Complexity Through Heterogeneity of Learner Actions

Basak Helvaci Ozacar

University of Calgary, Calgary, Canada

Abstract

Public computing is defined as a new form of open-ended, public learning environments, in which visitors can directly access, modify and create complex and authentic scientific work by interacting with open-source computing platforms (Sengupta and Shanahan, 2017). I argue in this submission that the theory of hybridity in the Third Space contextualized by Gutiérrez et al. (1999) can serve as a theoretical framework for creating public computing installations. Hybridity ties together the home, communities, and school for learners from migrant communities who feel marginalized in hegemonic schooling. Hybridity in Gutiérrez et al.'s (1999) context can be seen as a theoretical lens for both understanding and centering inherent diversity and heterogeneity of learners in activity systems and learning environments. It is therefore also a designerly way of organizing learning. Previous long-term ethnographic works by the authors also articulate how tension and conflict may result in the transformation of the activity, the participation, and the discourses, thereby the authors further conceptualized the concept of the third space. Thus, in this paper, they expanded the concept of Third Spaces and mention their hybridity given the polycontextual, multi-voiced, and multi-scripted nature of learning contexts, that value the conscious and strategic use of linguistic repertoires, creation of new contexts of development fostered language and literacy development. Situated in between official and unofficial spaces, the hybrid language practices that emerge in Third Spaces become the central mediating tool that helps unfold the possibility of dialogue and interpretation (Bakhtin, 1981) in public computing, and help minoritized learners find their voices even in technoscientific disciplines (Kayumova & Sengupta, 2022).

Virtual Parallel Session - 3.4 (Oral Presentations)

17:00 - 18:30 Friday, 1st September, 2023

Chair: Maria Inês Ribas Rodrigues

1065 Spaces for Multilingualism? Multilingual Approaches and Activities in Mathematics and Science Education

Annika Karlsson, Pia Nygård Larsson, Petra Svensson Källberg, Anders Jakobsson

Malmö University, Malmö, Sweden

Abstract

The purpose of the interdisciplinary project is to generate knowledge about the pedagogical potentials and limitations of multilingual practices in mathematics and science education. We specifically aim to explore and problematise how multilingual approaches and activities may promote mathematics and science teaching and learning in school years 4–9. The qualitative project is conducted by an interdisciplinary research team that integrates theories from educational research in didactics, sociology and linguistics, including translanguaging theories. The project's four-year period comprises initial exploration of existing pedagogical practices, mainly through workshops with teachers, classroom observations and interviews with students and teachers, in four culturally and linguistically diverse schools. This explorative phase is followed by a two-year period of pedagogical interventions, in which teachers and researchers together design, carry out and analyse classroom interventions. The interventions involve exploring the pedagogical potentials and limitations for promoting multilingual resources for teaching and learning. Further, students' identities as engaged learners of mathematics and science are explored. Our ambition is for the project to contribute with new and multifaceted knowledge on the complexity of teaching and learning in multilingual mathematics and science classrooms in mainstream compulsory schools in which the students have a variety of language backgrounds.

1157 Science Identities of Female Students During Peer Work: Gender, Dialogue, and Power in Chilean Sciences for Citizenship Classroom.

Helena Salas

UAH, Santiago, Chile. UDP, Santiago, Chile

Abstract

This project is a doctoral thesis dissertation that focus in understanding how female students develop science identities in secondary schools, in new pedagogical science settings that encourage collaborative peer interactions and problem solving. In Chile, reopening of schools coincide with the implementation of the 2019 curricular reform that include the new interdisciplinary course "Science for Citizenship", which precisely promote a new collaborative

and problem-based science. However, considering the historical gender gap that affect female students, a challenge remains: to what extent do these transformations address the gender gap issue? Based on sociocultural theory, it is argued that learning, emotions and identity are intertwined in peer interactions, and social categories as gender, ethnicity/race and SES intersect to produce different inequalities for female students in the science classroom. In this context, the research question is: How do the science identities of female students develop when they discuss with their peers in the Sciences for Citizenship classroom? The methodology selected is qualitative case study. Specifically, it is expected to follow, during 2023, a science secondary course in a Chilean low SES public school. The project is expected to contribute to meet the challenges of a comprehensive education where underrepresented students had more chances to learn, to be listened to and be identified with science, and to professional development focused in constant reflection of educational practices. By the time of the seminar, it is expected to present preliminary results from the initial phases of the field work and to discuss challenges and future steps of the project.

1214 Human Rights-Based Science Teacher Education: Rural Education and Education for Deaf People in Brazil

Danila Ribeiro-Gomes[1,2], Cristiano Mattos[2]

[1]Federal University of Viçosa, Viçosa, Minas Gerais, Brazil. [2]Programa de Pós-Graduação Interunidades em Ensino de Ciências da USP (Interunit Graduate Program in Science Teaching at the University of São Paulo), São Paulo, São Paulo, Brazil

Abstract

In the current context of curricular changes worldwide, which UNESCO guidelines have oriented, the Brazilian science teacher training degree courses have been considered inclusive, especially in Rural Education, which aims peasants, and because of the admission of the Deaf. However, this audience, who had studied in Brazilian public basic education, has manifested science educational gaps which must be decreased through science teacher education. Focusing on this problem, this research aims to UNESCO guidelines for curricular reformulation and how it is related to inclusive science teacher education, which aims the target audience of Rural Education and Deaf people. Therefore, a comparative bibliographic study was made in order to identify similarities between curricular guidelines in UNESCO documents and literature about these inclusive education fields. The outcomes revealed that human rights could be considered the main UNESCO guideline regarding actual world curricula reforms. This aligns with the inclusive educational principles of Rural Education and Education for the Deaf, which advocates respect and appreciation for human multicultural diversity. For science teacher education, this implies promoting dialogue between science and the multicultural systems of knowledge, practices, and learning directed to real-life.

1228 Girl Science - Science Girl: Challenges and Opportunities to Female Representation in the STEM Field

Maria Inês Ribas Rodrigues, Diana Roque, Raquel de Assis, Stephani Pereira

Federal University of ABC, Santo André, SP, Brazil

Abstract

Much has been discussed about the lack of female representation in the sciences, however, the main roots for this phenomenon are still poorly understood. The outreach project Girl Science - Science Girl (GSSG) from Federal University of ABC (FUABC) in Brazil was created to bring girls in middle school age closer to this field, aiming to minimize this gender paradigm. According to the World Economic Forum's Global Report on Gender Gaps in Science, gender parity will be achieved in more than 130 years. This present research seeks to investigate and analyze how female scientist representation in the GSSG 2021 edition can influence the humanization of the figure of the scientist and bring girls closer to science. The results point to the awareness of the participating girls about the relevance of women's work in the scientific world. We believe that proposals such as those of the GSSG should be considered potentially positive to expand the number of women in the STEM area in the future.

Virtual Parallel Session - 3.5 (Oral Presentations)

17:00 - 18:30 Friday, 1st September, 2023

Chair: Jianyun She

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187 Comparison of the Teacher Identity Perception of Novice Science Teachers through a Mixed-Methods Approach

Jorge Luque-Jimenez, Cristina Garcia-Ruiz

University of Malaga, Malaga, Andalucia, Spain

Abstract

Despite research on teacher identity contributes to understanding teacher learning and development, studies carried out with novice teachers (with less of five years of professional experience) are still rare due to the difficulties of finding participants at this stage. Consequently, this study aims to know how novice science teachers perceive their teacher identity through a mixed-methods approach. Hence, we have compared the data collected from an open-question survey and a Likert-type questionnaire adapted from literature to seek for matching results, evidencing in this way the consistency of these novice teachers' perception about their teacher identity. Results show how pre-service teaching training provided novice teachers with a notion of their teacher identity, establishing the differences and similarities with other educational stages, and highlighting the factors, such as the Master´s Degree, placement

period or teacher motivation, that have an influence in constructing their teaching identity.

574 Plant Awareness Disparity on Image Description by Brazilian Teachers

João Paulo Reis Soares, Carolina Maria Boccuzzi Santana, João Rodrigo Santos da Silva

Federal University of ABC, Santo André, São Paulo, Brazil

Abstract

Plant awareness disparity is a phenomenon that profoundly affects botany education. Furthermore, it is related to conservation issues. Therefore, considering the importance of teachers to the educational process, this paper aims to understand how the component of attention and relative interest influences the analysis of images about biodiversity by Science and Biology teachers and student teachers. participants described mostly animals rather than plants, regardless of their position in the image. Additionally, they also named plants more generically than animals. Therefore, it is important to approach these differences in biodiversity knowledge and perception in teacher education.

728 Nature of Science in Teacher Professional Development: In-Service Teachers' Perceptions and Strategies for Integration

Haya Ben Simon, Anna Pshenichny-Mamo, Dina Tsybulsky

Technion, Haifa, Israel

Abstract

Nature of Science (NOS) is a concept that relates to what science is, how science works, which questions science can answer, and which it cannot. In the professional literature there are several known teaching methods for integrating the NOS in instruction. However, the perceptions that in-service teachers hold regarding these methods have not been sufficiently examined. This study examines the contribution of the course "NOS in post-elementary schools" to the perceptions held by teachers studying for advanced degrees in science education regarding the integration of NOS in lessons. We also examine its impact on their choice of pedagogies for the integration of NOS. Based on lesson plans that the teachers wrote and implemented, their reflections on the learning process, and semi-structured interviews, we find that participation in the course boosted the importance, in the teachers' eyes, of teaching the NOS and integrating it in lessons. Their perceptions reveal a new understanding and new familiarity with different methods of implementation for teaching NOS in their lessons. We found that the most common teaching method in the lessons they taught was the "Narrative of Inquiry." The factors taken into account when choosing a method were creating interest, suitability to the aspect of NOS which they wanted to discuss, and personal ease. These findings show the importance of including a course that engages with education for NOS as part of teacher education, one which, along with teaching theory, teaches teaching methods in practice.

729 Is Teacher's Pedagogical Content Knowledge Related to Student Academic Achievement?

Jianyun She, Kennedy Kam Ho Chan

Faculty of Education, The University of Hong Kong, Hong Kong, China

Abstract

This paper provides solid empirical evidence on the relationship between biology teachers' pedagogical knowledge (PCK) and students' academic achievement. 147 7th grade Chinese biology teachers participated in tests in which teachers' two forms of PCK - the more static and declarative PCK and the more dynamic and situated PCK for teaching photosynthesis - were assessed using a text-based PCK test and a video-based PCK test, respectively. Their students (N = 5,530) also attempted pre-post achievement tests which are closely aligned with the teachers' PCK tests. Analysis using two-level hierarchical linear modelling revealed a significant, positive association between levels of the two forms of PCK and student achievement. Significantly, the more situated and dynamic form of PCK assessed by the video-based test predicted student achievement (the proportion of variance explained, PVE = 0.426) better than the more declarative and static form of PCK assessed by the text-based test (PVE = 0.313). These findings provide much needed evidence to support the basic premise of PCK research that teachers' PCK is related to student learning.

Virtual Parallel Session - 3.6 (Oral Presentations)

17:00 - 18:30 Friday, 1st September, 2023

Chair: Ángel Vázquez-Alonso

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921 Varying Conceptual Structures: How Knowledge Pieces Interacted When a Grade 7 Student Justified What Was Matter in Different Contexts

Annie Kam Lam Chan[1], Maurice M. W. Cheng[2]

[1]Faculty of Education, The University of Hong Kong, Pokfulam, Hong Kong. [2]Te Kura Toi Tangata School of Education, University of Waikato, Hamilton, New Zealand

Abstract

Student ideas – even after learning – are often found to be diverse and alternative to scientific understandings. These ideas are considered products of the dynamic interaction between conceptual resources represented in memory. While numerous studies have focused on conceptualizing different types of conceptual resources and explaining the nature of student ideas (e.g., robust versus transient, consistent versus inconsistent) in terms of their organization (e.g., isolated versus organized network), there are limited studies investigating the change and constancy of the connections between these resources across contexts and their possible

interactions. This paper presented part of the findings from a study that investigated the possible interactions among the repertories of knowledge pieces, when Grade 7-8 students reasoned about the change and constancy of matter in the human growth, plant growth, and food chain contexts. In the study, a knowledge piece is defined as a conceptual resource corresponding to "a perceived regularity in events or objects, or records of events or objects, designated by a label". The data used in this paper was garnered from a one-hour individual interview with a Grade 7 student after he has learned about matter, physical and chemical changes at the particle level. Drawing upon the construct "adherence", the data was analyzed using relational concept mapping. It is found that the student's repertoire of knowledge pieces was similar but the conceptual structures varied when he justified what was matter in the human growth and food chain contexts. The differences in the conceptual structures could be explained by the competition between CELLS and PARTICLES and the activation of the connection between MATTER and LIVING THINGS. Our findings contribute to an understanding of dynamic interaction between knowledge pieces and inform how classroom talk can be designed to induce/strengthen desirable connections between knowledge pieces.

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931 Curupira and Caipora: An Analysis of the Potential of Brazilian Indigenous Narratives for Science Teaching

Letícia Chini de Castro, João Gabriel di Marco Silva, Marcelo Tadeu Motokane

University of São Paulo, Ribeirão Preto, São Paulo, Brazil

Abstract

This study aims to identify the educational potential in Brazilian indigenous narratives of Caipora e Curupira for science teaching. These popular narratives about mythical figures that protect forests are found all over Brazil. The research approach is qualitative. The data presented in this article come from an analysis of 15 prose texts. We performed a document analysis using discursive textual analysis (DTA). After, the excerpts from the texts were categorised. The findings show that the narratives are found throughout the entire territory of Brazil, reaching different ages and preserving a conservationist background.

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844 The Role of Character Education in Promoting Environmental Sustainability: A Systematic Literature Review

Najwa Huda Shaharil[1], Sharifah Intan Sharina Syed Abdullah[1], Norshariani Abd Rahman[2], Fathiyah Mohd Fakhruddin[1]

[1]Universiti Putra Malaysia, Serdang, Selangor, Malaysia. [2]Universiti Kebangsaan Malaysia, Bandar Baru Bangi, Selangor, Malaysia

Abstract

Character education has emerged in the last two decades as a result of the mainstream educational system's failure to generate morally upright and holistic individuals. There are also numerous studies on the use of Character Education to promote environmental stewardship

among students. Nevertheless, comprehensive and systematic studies on the intersection of these topics are limited. Accordingly, this study is conducted to overcome this gap. The review processes included fve key methodological steps, namely guided by PRISMA review protocol, formulation of research questions, systematic searching strategies based on identifcation, screening, and eligibility on several databases such as Scopus, Web of Science, Science Direct, and Google Scholars, followed by quality appraisal, and data extraction and analysis. A total of 20 articles met the criteria for thematic-qualitative analysis. This study finds that educational and family institutions are the key stakeholders that become the determinants of success of this approach. There are also three key strategies to employ Character Education to improve students environmental stewardship within the educational instutions which include curriculum, extra-curriculum and habituation. Meanwhile, there are three main sources that play a role in providing the values that are internalized in the approach to promote environmental stewardships among students which are religion, local culture and unversalism.

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624 Implementation of Act 27,642 About Healthy Diet Promotion in a Secondary School of Argentina Based on the Roses Project

Damian Lampert[1], Leandro Anibal Crivaro[2], Silvia Porro[3], Ángel Vázquez-Alonso[4]

[1]Universidad Nacional de Quilmes / CONICET, Quilmes, Buenos Aires, Argentina. [2]Facultad de Ciencias Jurídicas y Sociales, Universidad Nacional de La Plata, La Plata, Buenos Aires, Argentina. [3]Universidad Nacional de Quilmes, Quilmes, Buenos Aires, Argentina. [4]Instituto de Investigación e Innovación Educativa, Universidad de las Islas Baleares, Palma, Spain

Abstract

The central aim of this research is to know the attitudes and interests of a chemistry course students in a secondary school in Argentina as regards nutrition in order to develop an adequate didactic sequence. To get to know the interests about nutrition, the relevant items of the ROSES (the Relevance of Science Education - Second) questionnaire were used. Based on its results, most of the students are interested in food production and preservation, and in healthy diets. Besides, a didactic sequence focused on the front-of-package nutrition labeling and its subsequent reading was developed. The didactic sequence was positively valued by students in relation to its usefulness, their interest, and a critical citizenship formation. The didactic sequence and students' interests coincide with the content proposed by Act 27,642 about healthy diet promotion by introducing food education in schools to exercise the right to health and nutrition.

Virtual Parallel Session - 3.7 (Oral Presentations)

17:00 - 18:30 Friday, 1st September, 2023

Chair: Miriam Palma-Jiménez

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863 Facial Emotion Recognition in Science Education Research: Preliminary Results in Inquiry Based Activities

Sonia Pamplona[1], Miguel Ángel Fuertes[2], Radu Bogdan Toma[3], Iván Ezquerra-Romano[4], Rafael Campillos[5], Marta Reina[6], Marta Ceballos[6], Beatriz Pérez Bueno[6], Ángel Ezquerra[1]

[1]Universidad Complutense de Madrid, Madrid, Spain. [2]Universidad de Salamanca, Salamanca, Spain. [3]Universidad de Burgos, Burgos, Spain. [4]University College London, London, United Kingdom. [5]Universidad Camilo José Cela, Madrid, Spain. [6]Fundación San Pablo Andalucía CEU, Sevilla, Spain

Abstract

During the last years, emotions and attitudes towards science have been one of the fastest growing research topics (Melo, Cañada, & Mellado, 2017). The value of these themes stems from the evidence that the individual and social perceptions towards science have meaningful effects in society, on economy, health (Brewer et al., 2007), democratic participation (Levinson, 2010), personal decision making (DeBoer, 2000), environmental care (Kahan et al., 2012) and, obviously, education. However, most studies on emotions in education have collected data using the observation or declaration methods. Now it is possible to use biometric or neurophysiological methods.

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450 The Use of Augmented Reality in Biology Subjects in the Context of Technology Integration into Education

Sonay ŞAHİN AYDEMİR[1], Esra KIZILAY[2], Nagihan TANIK ÖNAL[3], Aslı SAYLAN KIRMIZIGÜL[2]

[1]Ministry of National Education, Kayseri, Turkey. [2]Erciyes University, Kayseri, Turkey. [3]Niğde Ömer Halisdemir University, Niğde, Turkey

Abstract

This study aims to explore teachers' views on the use of AR. In addition, AR has many advantages in teaching abstract subjects that cannot be observed in the classroom under normal conditions. This feature highlights the use of AR in science lessons. However, studies dealing with biology are limited in number. In this context, the study aimed to investigate science teachers' views on the use of AR in teaching biology subjects. This phenomenological research carried out with the participation of six science teachers. The data were collected through semi-structured interviews and analyzed by using descriptive and content analyses together. According to the findings, participants' views on technology integration and the use of AR in biology were generally positive. Participants thought that the use of AR in biology

subjects has advantages such as embodying abstract subjects, being fun and interesting, providing permanent learning for students, and increasing motivation for the lesson. On the other hand, some teachers stated that the continuous use of AR has disadvantages such as eliminating the effect of innovation by causing a mundaneness, and that its use requires a certain knowledge of technology. According to the findings, teachers mostly use AR applications in the subjects of "systems", "cell and organelles" and "diversity of living things". The most preferred AR applications are Quiver, Anatomy 4D, Animal 4D+ and Humanoid 4D+. In line with the results of the research, suggestions were made such as generalizing the use of AR in biology subjects and giving practical training to teachers about this.

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331 Promoting Critical Thinking Skills Through Debates in Engineering Education: A Case Study on Manufacturing

Jose Manuel Hierrezuelo Osorio, María José Cano Iglesias, María del Mar López Fernández, Antonio Joaquín Franco Mariscal

University of Málaga, Málaga, Spain

Abstract

Argumentation and decision-making are fundamental in the training of industrial engineers to effectively develop their critical thinking skills. Despite this, engineering education focuses on technical aspects that hardly promote the development of these skills in the classroom. To promote them, a specific training programme in critical thinking for industrial engineers was proposed, which, among other activities, included short debates on socio-scientific problems. This paper presents the impact of a debate on manual versus mass production on 30 students of the Degree in Industrial Technologies Engineering at the University of Malaga (Spain) acting as listeners. To assess this impact, we analyse the argued decisions made by the listeners about the problem before and after the activity, finding that the initial position of the majority was manual manufacturing based on social evidence, and the final position was mass production based on scientific-technical evidence such as economic aspects or the quality of the manufactured product. The arguments used by the debaters were scientifically vague but had an essential effect on changing decisions, especially the evidence used, which the listeners made their own.

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188 Arguments Used by Preservice Elementary Science Teachers for the Preparation of a Role Play about the Controversy of Breast Milk Vs Formula Milk

Miriam Palma-Jiménez, Daniel Cebrián-Robles, Ángel Blanco-López

University of Malaga, Malaga, Spain

Abstract

In science education, socio-scientific problems have been proposed as suitable contexts for learning science and scientific argumentation because of their characteristics: they are open, poorly structured, debatable and subject to multiple perspectives and solutions. One way to

approach them educationally is through role play. This study involved 68 preservice elementary science teachers at the university during the 2019/2020 academic year. We wish to know what dimensions are found in the arguments made by the students to prepare their roles in a role-play activity. The context of the controversy of choice between breastfeeding or formula feeding is part of the socio-scientific problem of human breastfeeding. The role play helped us know what variability of dimensions we found in this socio-scientific problem in preparing the role arguments. The pro-breast milk feminist and the breast milk activist roles stood out in various dimensions. Regarding the type of dimensions most used, baby's health was the most used. This context was useful for approaching health topics.

Virtual Parallel Session - 3.8 (Oral Presentations)

17:00 - 18:30 Friday, 1st September, 2023

Chair: Irene Drymiotou

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80 Science as Architect of Femininity and Masculinity

Míriam Comet Donoso[1,2], Sònia Estradé Albiol[1,2], Pilar Folgueiras Bertomeu[1,2]

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Abstract

Science has overseen defending that natural is equivalent to normal and, on many occasions, has argued that anatomy and physiology are what determine our social practices, thus justifying systems of oppression and defending that there are behaviors that are biological and that have nothing to do with education or culture. In the present work, it is intended to expose some of those stories that have been said from science, trying to justify the supposed essentiality of masculinity and femininity. More specifically, we will talk about some of the scientific myths in relation to the misnamed sex hormones that have served as arguments to build the measuring stick of the archetypes of what is considered correct versus what is not of the feminine and masculine and thus laying the biological and therefore unquestionable, bases for inequalities.

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195 Analysis of Educational Interactions in Science Class from the Framework of the Knowledge Quartet

Jaime Solís[1,2], Christian Miranda[2], Cristian Merino[1], José Luis Medina[3]

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Abstract

In the context of COVID-19, the society of information and knowledge has defied these concepts to be prepared for the massive influx of fake news. In order to encourage the responsible selection of information and empowerment facing contingency themes, the socio-scientific problems facilitated spaces to address concepts of sanitary interest and empower the students in their personal choices within open spaces of negotiation of meanings. To that end, the teaching practices included activities which, through language, seek to promote learning and developing social, intellectual, and creative skills, known as Educational Interactions -EI-. Currently, PCK models in science assume the inability to establish a specific relationship between the teacher-student interactions. One opportunity comes from the field of mathematics, known as "Knowledge Quartets." It considers interactive elements within the classroom, showing flexibility towards other disciplines. In order to evaluate the plausibility of observing science teachers' behaviours from the KQ framework, a multiple case study of two science teachers was conducted in order to identify episodes relevant to describe their perceptions and propose EI typologies. When triangulating observation techniques, stimulated recall interviews and the KQ framework, a dialectical analysis was conducted from the data that characterizes the EI's in three dimensions, conceptual, reflexive, and dialogic-epistemological, making it a viable tool in order to understand relational elements that mobilize knowledge while the students transition from their alternative ideas toward new understandings of natural phenomena.

288 How Biology Education and Religious Education Teachers Diagnose Student Attitudes on Creation and Evolution

Tobias Hoppe[1], Christiane Konnemann[2], Christian Höger[3], Alexander Renkl[4], Werner Rieß[1]

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Abstract

Accurate judgments of students' attitudes concerning creation and evolution are a necessary condition for individual support in both biology education and religious education classrooms. While some studies have assessed the attitudes of students and teachers, little is known about how teachers themselves arrive at appropriate judgments of students' attitudes. This study aims to elucidate the diagnostic judgment processes of noticing and interpreting related to learners' attitudes concerning creation and evolution. In doing so, we want to capture the influence of person characteristics of the judging (prospective) biology and RE teachers on diagnostic performance. The results contribute to the design of learning environments in which teachers' diagnostic skills can be effectively fostered.

698 The Value of Open Schooling in Tackling the Silent Pandemic of Antimicrobial Resistance

Irene Drymiotou, Costas Constantinou

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Abstract

The scope of this study is to explore the role of an open schooling mechanism in enhancing students' interest in science and broadening their understandings of relevant careers. Framed within the design-based research paradigm, we have adopted a case study approach to enact an open-schooling teaching-learning sequence around the socio-scientific issue of antimicrobial resistance according to which students are being engaged in scientific practices and collaborate with various stakeholders from the wider community. The participants are 43 students (13-14 years old) attending an urban secondary school. Data were collected with the use of a questionnaire and structured interviews at two evaluation points. Preliminary findings from the ongoing study indicate that students' authentic engagement in scientific practices using actual research equipment with experts has triggered their interest and has served to enrich their perceptions of science and strengthen their understandings of science careers. The findings are potentially useful in improving the design of open-schooling teaching and learning activities and in formulating practical recommendations for curriculum design and classroom practices for enhancing students' interest in science and relevant careers.

Virtual Parallel Session - 3.9 (Oral Presentations)

17:00 - 18:30 Friday, 1st September, 2023

Chair: Bhaskar Upadhyay

1257 Students Learning outcomes in Problem-Based Guided Inquiry Chemistry Laboratory Courses

Frackson Mumba[1], Ryoo Ji Hoon[2], John Ojeogwu[1]

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Abstract

This study investigated the association between students learning, attitudes towards science and perceptions of Project-Based Guided Inquiry (PBGI) chemistry labs. In the PBGI labs students solve a real-world problem over time through the systematic analysis of data and are given guiding questions to support the development of investigations to answer the problem. This study addressed three research questions: What is the impact of PGBI labs on students' content knowledge, attitude towards science, and perceptions of PGBI labs? What associations

exist between students' learning, perceptions, and attitudes and in chemistry PBGI labs? What factors contribute to the students' success, or lack thereof in PBGI chemistry labs? Participants were 3992 students enrolled in general chemistry lab courses. We employed a one group pre-post experimental design. There was a significant difference between pre-post-tests scores on students' chemistry content knowledge, attitude towards science, and perceptions of PBGI labs. Inquiry skills and Laboratory skills were significantly predicting the student's performance on chemistry content knowledge test.

983 Examination of Primary Teachers' Opinions on Scientific Argumentation Skills and the Use of Argumentation in the Science Course

Muhammet Musab GÜMÜŞ[1], Demet Şahin Kalyon[2]

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Abstract

The purpose of this study was to investigate the primary teachers' opinions on scientific argumentation skills and the use of argumentation in the science course. Argumentation is a significant part of scientific knowledge production, and the science classes is full of opportunities to use argumentation. The study is quantitative research and the correlational research design of the general survey model, one of the quantitative research methods, was used. The study group of the research was the primary teachers working in public primary schools which were selected through an appropriate sample in a province of Southeastern Anatolia in the 2021-2022 academic year. At the end of the study, when the scores of the primary school teachers in the scientific argumentation test were examined, it was seen that the primary teachers had moderate argumentation knowledge. In addition, when the average value of the factors affecting the argumentation practices used in the study is examined, it can be said that the average scores of the primary teachers is high. In this case, it is possible to say that the primary school teachers feel competent in teaching argumentation. When the scores of the primary teachers in the scientific argumentation test and the values they received on the scale of factors affecting their argumentation practices were examined, no statistically significant relationship was found between the scores. Finally, it is suggested that research on argumentation should be conducted mainly for teachers working in primary schools, organizing theoretical and practical in-service training for primary school teachers about the argumentation methods, and designing projects related to the argumentation method to include primary school teachers.

789 "Gaijatra": Leveraging Cultural Heritage of Emotions in STEAM Teacher Professional Development in Nepal

Bhaskar Upadhyay[1], Cuc Vu[1], Stephanie Erickson[2]

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Abstract

This paper qualitatively explores Nepali teachers' experiences learning about incorporating the local cultural heritage of Gaijatra in STEAM teaching. Utilising culturally sustaining/relevant pedagogy and human emotions as the theoretical frameworks, the authors show that the inclusion of local cultural heritage in STEAM professional development brings enthusiasm and a sense of connection among STEAM teachers' interest in making teaching more culturally relevant/sustaining. However, cultural heritage also generates emotions of ambivalence among teachers when success is measured through standard Western science. The study contributes to science education by showing the value of local heritage in STEAM teaching and learning.

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355 Reflection of the Science Program on Student Teachers and Parents

Şule Elmalı, Ahmet Burak Şenöz, Fatime Balkan-Kıyıcı, Elif Atabek-Yiğit

Sakarya University, Sakarya, Turkey

Abstract

The main function of the curriculum is to shape the changing needs of individuals and societies over time in parallel with the new developments in educational approaches. In this context, the main purpose of the science curriculum is to raise individuals as science literate (MEB, 2018). There are three sides teachers, students, and parents, who are expected to be in harmony with each other for the science curriculum to achieve this goal. Therefore, only evaluating students and providing data from them is insufficient when evaluating the curriculum. In this context, this study is aimed to investigate how the reflection of the science lesson curriculum on teachers, students, and parents. The study, which was designed according to the case study pattern, data of the study was obtained by interviewing the teachers, students, and parents of a secondary school located in the central district of Sakarya province, which was determined based on the convenient sampling method. Interviews with teachers, students, and parents were conducted face-to-face or via telephone under semi-structured interview protocols and recorded with permission. The analysis of the obtained data was carried out with content analysis, and the findings were presented. As a result of the study, the main purpose of the curriculum as "raising scientifically literate individuals" is partially achieved. While teachers, students, and parents agree that the purpose of the science lesson is to teach various information, a limited number of students and parents have stated that science is a part of life, it is the way we can apply when looking for solutions to the problems we encounter in our daily life, and in this context, it is effective in gaining skills.

Virtual Parallel Session - 3.10 (INVITED WORKSHOP)

17:00 - 18:30 Friday, 1st September, 2023

1317 Invited Workshop: Getting your ideas into print: Planning, developing, and publishing a book in the ESERA Series

Claudia Acuna[1], Manuela Welzel-Breuer[2], Giulia Tasquier[3]

[1]Springer, Dordrecht, Netherlands. [2]University of Education Heidelberg, Heidelberg, Germany. [3]University of Bologna, Bologna, Italy

Abstract

The aim of this workshop is to inform and assist ESERA members who might be considering – however tentatively – writing a book or putting together an edited collection of chapters by different authors, in order to share their work and ideas with the wider science education community. It will start by exploring general issues about publishing your work and then focus on publishing in the ESERA Book Series Contributions from Science Education Research.

The ESERA Book Series was set up in 2013. The aim of the series is to enhance the quality and impact of research in science education in Europe by presenting the findings of high-quality research and scholarship and in-depth explorations of specific methodological strands in science education research. The series offers ESERA members the support of an Editorial Board in planning and developing a sound proposal, and crafting a manuscript that makes a strong contribution to the science education research literature. It also facilitates the dissemination of the authors' work and ideas, through attractively low prices for ESERA members of printed and electronic copies of books in the series.

The workshop will involve short presentations and opportunities for questions from participants. We will outline and discuss the development of a proposal, explain how this is reviewed by the Editorial Board, and discuss the steps involved in taking a proposal forward to publication. We will explain how authors and editors are supported by the Editorial Board after a proposal has been accepted, and how the manuscript is reviewed in order to enhance and assure its quality. The workshop will draw on the experience gained from previous books in the series, including some that are in progress. We hope the workshop will encourage more ESERA members to consider the series as an ideal outlet for their work.

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