RUHR-UNIVERSITÄT BOCHUM

Earli

RUB

EARLI SIG 20
COMPUTER-SUPPORTED INQUIRY LEARNING CONFERENCE

Theme: Promoting Science Through Inquiry

22-24 August 2012
Bochum, Germany

Institute of Educational Research, Educational Psychology Research Group

Conference Website:
www.pp.rub.de/earlisig20

Host:
Educational Psychology Research Group
Institute of Educational Research
Ruhr University Bochum
Universitätsstraße 150
44801 Bochum
Germany
Website: http://www.pp.rub.de

Organisation:
Dr. Astrid Wichmann

Welcome

Welcome to Bochum!

EARLI and the Institute of Educational Research at the Ruhr University welcome you to participate at the computer-supported inquiry learning conference entitled “Promoting Science Through Inquiry”, August 22-24, 2012 at the Ruhr University in Bochum, Germany.
Along with the brilliant science we all expect, it is also a pleasure for us to give you a better understanding of our beautiful region during the course of this conference.
The city of Bochum is located in the heart of the Ruhr area - the Ruhrgebiet. The Ruhr area is often associated with the mining industry, filthy streets and hard-working people. We are proud to say that this is all true! The Ruhr area has a long industrial history and living here always included plenty of laborious work. This, though, is only one side of the coin. The region has transformed itself into a true melting pot of cultures – Not by chance it was honored as the 2010 European Capital of Culture! You can discover a wide variety of international and multicultural influences throughout this open-minded region as well as a huge amount of art, theater, science, and of course soccer. Bochum offers many examples of this diversity. For instance, the Botanic Garden, which is only a 10 minute walk from the University, is an emblem of the local method of combining nature and art or the Zeiss Planetarium which offers you to immerse yourselves into a stunning cosmic world by using innovative technology. Naturally the Ruhr area's industrial background is an important part of its culture as well. The Deutsches Bergbau-Museum in Bochum, e.g., is the largest mining industry museum in the world. Another example is the Jahrhunderthalle which is a unique venue for exhibitions about the history of general and local, mining and heavy industry, as well as pop culture events such as concerts or film festivals.
As you can tell, the Ruhr area's diversity cannot be easily described in just a few sentences. Now it is your turn to discover the beauty and diversity this region has to offer!

The EARLI SIG 20 organizing committee

General Information

Address
Ruhr University Bochum
Educational Psychology Research Group
Universitätsstraße 150
44801 Bochum
Germany

Registration
The conference venue is at the Ruhr-University at Beckmanns Hof, the international Convention Centre.
The registration is open Wednesday 22nd from 14:00 h.
If you have any questions during the conference, please call (+49) 173 51 44077 (Astrid Wichmann).

Scientific Programme
We have two distinguished keynote speakers: Wouter van Joolingen (University of Twente, NL; August 23rd, 11:00h) and Janice Gobert (Worcester Polytechnic Institute, US; August 24th, 10:00h) .
All talks will be held in the room "Neuer Saal" at Beckmanns Hof. Paper presentations are organized in thematic sessions. A paper presentation will take 17 minutes + 5 minutes for questions. Notebook, projector and presentation pointer will be available in each presentation room. Please bring your presentation on a USB stick. Alternatively you can also bring your own notebook and attach it to the projector. In each paper session a member from the organizing team will serve as chair.

Social Programme
The registration fees include (a) meeting registration, (b) programme & abstract book, (c) coffee breaks with drinks and appetizers, (d) one guided architectural tour at the Ruhr University, (e) reception on the first day. The dinner on the second day is not included in the registration fee.

Traveling

By plane
The biggest airports in Nordrhein-Westfalen are Düsseldorf International Airport and Cologne-Bonn Airport. This is where most of your flights will go to. When you arrive at the airport, the best way to get to Bochum is to go by train.

By train
From Düsseldorf International Airport:
Take the Skytrain to get to the station Düsseldorf Flughafen Bahnhof. Here you can take a Regional-Express that goes directly to Bochum main station. It takes about 35 minutes.

From Cologne-Bonn Airport:
Cologne-Bonn Airport includes a train station as well named Cologne-Bonn Airport. First take a train to Cologne main station and then change to one to Bochum main station. It takes about 90 minutes.

When you arrive at Bochum main station, you have to take the U 35 - a tram that takes you to Ruhr-University Bochum. The tram leaves from the underground in the main train station every 10 minutes. It takes about 10 minutes to get to Ruhr-University.

Taxi Company
- Taxi Bochum 0234-333 000
- TaxiBo 0234-79 800 79
- City Taxi 0234-600 300

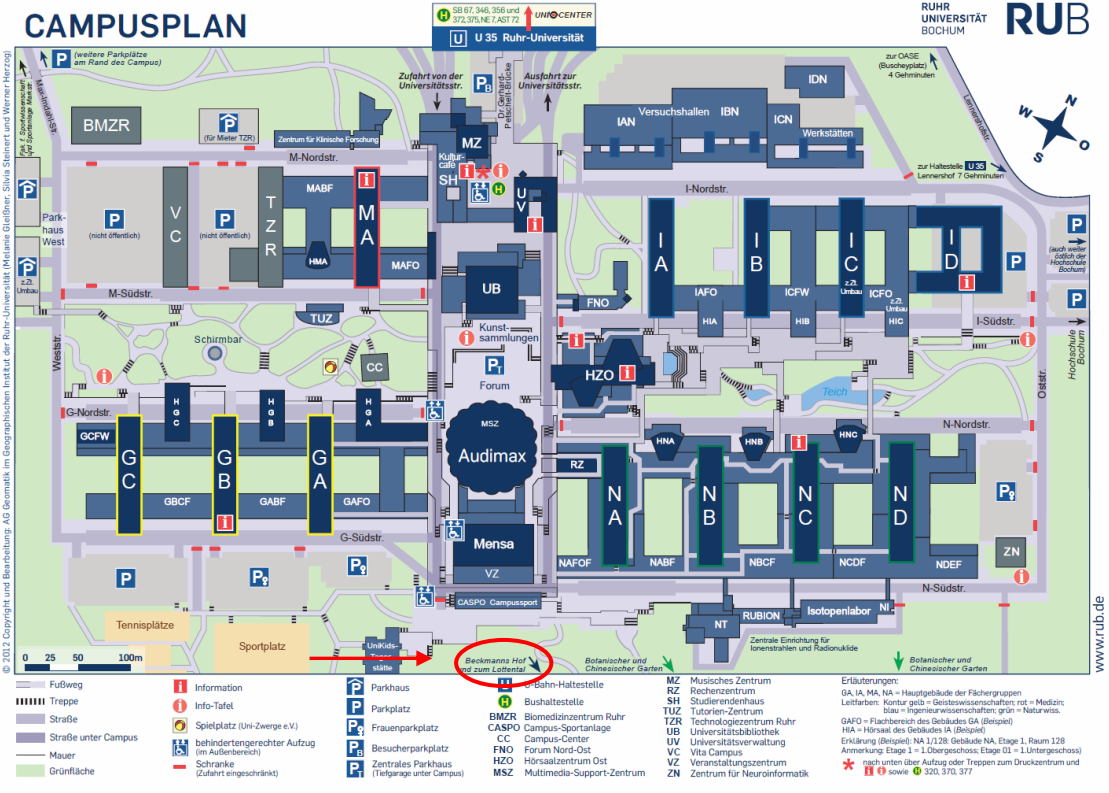
Tourist Information
Bochum Tourismus: 0234-96 30 20

Internet access
We provide access to W-Lan during the conference. In addition, there will be some conference notebooks available.

Catering
During the conference, there will be several breaks, including coffee and lunch breaks. Coffee breaks will take place at the conference venue Beckmann's Hof. For lunch, vouchers will be available to visit the nearby Mensa (University canteen). The Welcome Reception will include drinks and finger food. The conference dinner takes place at the Stadtpark Restaurant in Bochum.

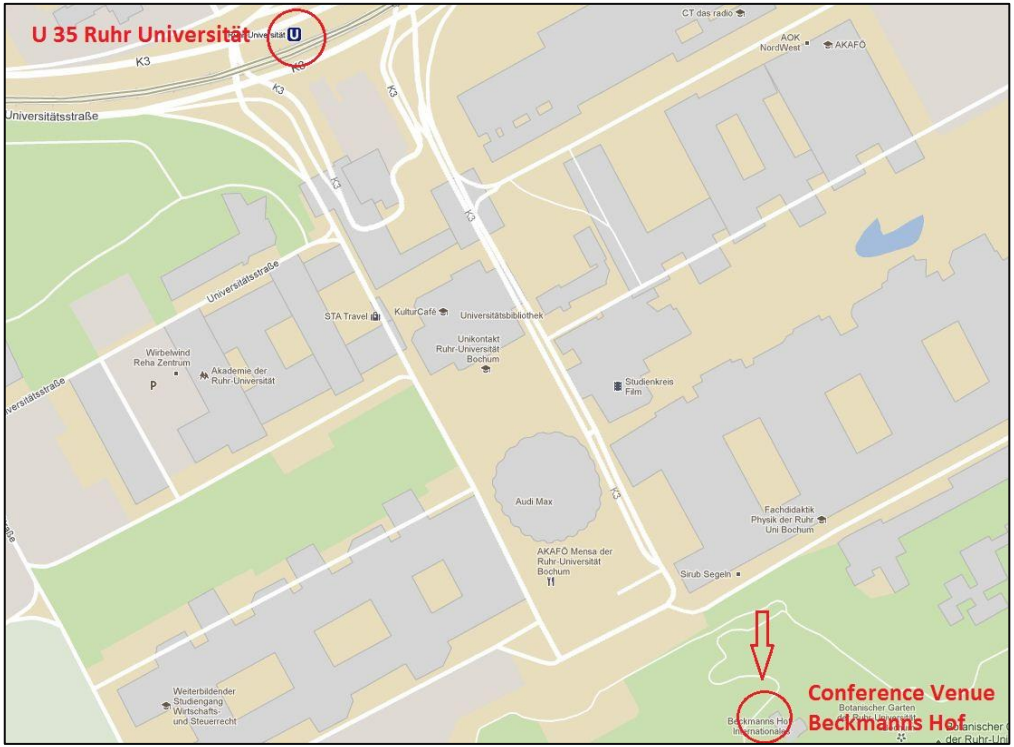
Maps

Map of the Campus



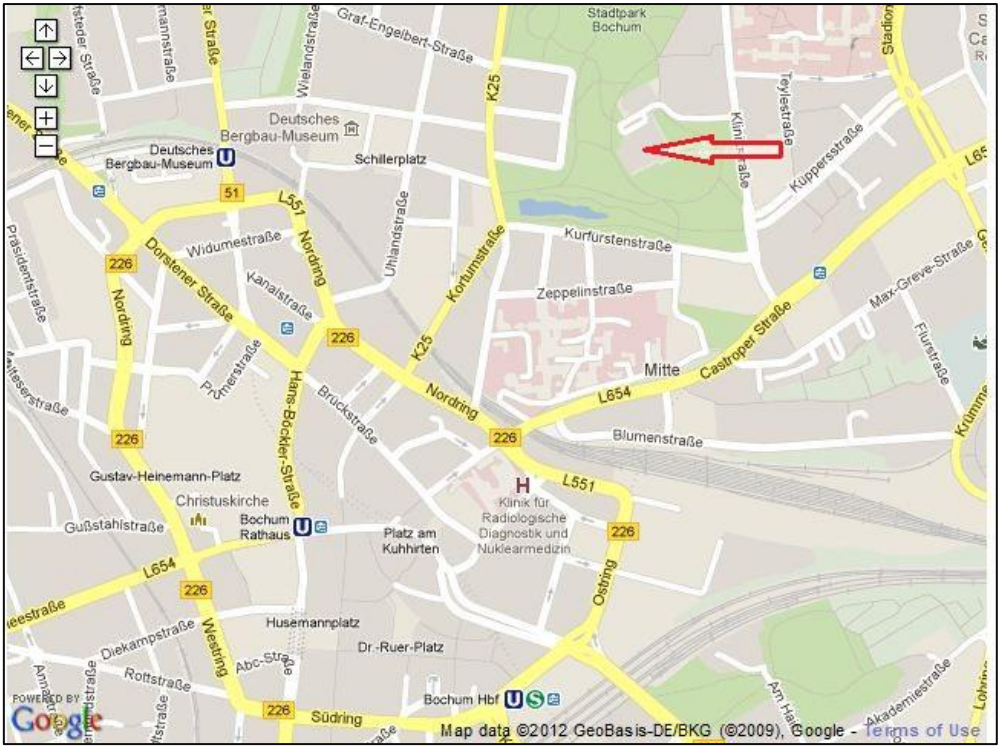
*Directions to conference venue **Beckmanns Hof** at the Ruhr University*

From Ruhr-Universität Bochum Tram station, take a right, and then go straight. Pass the Audimax on the right hand side, go down the stairs all the way down until you come to the end of the stairs. From there, follow the sign “SIG 20 Conference”. This walk takes about 15 minutes.



Directions to dinner venue ***Restaurant im Stadtpark*** *Bochum*

From Ruhr Universität or Bochum main train station, take the U-35 in direction of “Herne”, Get out at “Deutsches Bergbau Museum” in direction “Deutsches Bergbau Museum”. Walk past the Bergbaumuseum, turn into the Stadtpark. In the Stadtpark take the first left.



Programme

Wednesday, 22nd of August 2012

Time	
14:00 – 14:15	Registration
14:15 - 14:30	Welcome
14:30 – 15:25	Interactive Demo (invited)
	Janice Gobert, Ermal Toto, & The Science Assistments Team Science Assistments: Assessing and assisting students' scientific inquiry
	Wouter van Joolingen, Lars Bollen, Frank Leenaars SimSketch & GearSketch: Sketch-based modelling for early science education
	Jody Clarke-Midura, Chris Dede Virtual Performance Assessments: Measuring Students Ability to Reason from Evidence
15:25 - 16:30	Paper Session 1 - Productive Failure
	Natasha Holmes, Ido Roll, James Day, Doug Bonn Using metacognitive scaffolding to improve learning from guided invention activities
	Katharina Westermann, Nikol Rummel Should invention activities in a delayed instruction setting be guided?
	Heinz Kreutz, Katharina Franke Subject – context – tools: Emerging connections – the role of ICT in foreign language pedagogy
16:30 - 16:55	*Break*
16:55 - 18:00	Paper Session 2 - Scaffolding Inquiry Processes

	Yossy Machluf, Hadas Gelbart, Anat Yarden Characterizing the incorporation of bioinformatics into high school biotechnology curricula through a scientifically authentic learning environment
	Ard Lazonder, Alieke van Dijk Scaffolding students' use of learner-generated content during an inquiry-based science project
	David Tobinski, Annemarie Fritz-Stratmann, Walter Hussy Transforming a problem space: planning behavior through inquiry learning or instruction? The digital zoo-game approach
18:00 - 19:30	RUB Architectural Guided Tour
19:30 - 22:00	Welcome Reception with the Rector of the Ruhr University

Time	
09:00 - 10:30	Paper Session 3 - Simulations I
	Tomi Jaakkola, Koen Veermans Inclusion of perceptually abstract elements in a computer-based educational simulation in elementary school context: Reward or hazard?
	Arnon Hershkovitz, Ryan S.J.d Baker, Janice Gobert, Zakkai Kauffman-Rogoff, Michael Wixon Student attributes, affective states, and engagement in science inquiry microworlds
	Lars Bollen, Wouter van Joolingen Thinking with drawings - Sketch-based modelling in early science education
	Bas Kollöffel, Ton de Jong Combining traditional instruction and simulation-based inquiry learning in secondary vocational technical education: Effects on understanding
10:30 - 11:00	*Break*
11:00 - 12:30	Keynote **Wouter Van Joolingen**
12:30 - 13:30	*Lunch*
13:30 - 15:00	Session 4 - Collaborative Learning
	Alexander Scholvien, Daniel Bodemer Cognitive group awareness support for collaborative discovery learning
	Ingo Kollar, Christof Wecker, Sybille Langer, Frank Fischer Effects of small group collaboration scripts and classroom scripts on online search competence during a biology inquiry unit
	Christof Wecker, Ingo Kollar, Frank Fischer Fostering online search competence in an inquiry learning curriculum: Effects of continuous and faded collaboration scripts

	Annelies Raes, Tammy Schellens Scripting collaboration in web-based collaborative inquiry in face-to-face classroom settings
15:00 - 15:30	*Break*
15:30 - 17:30	Panel
	Ido Roll, Jody Clarke-Midura Towards a shared grammar: Logging and analyzing interactions across a variety of inquiry environments Panelists: **Kathy Perkins, H. Ulrich Hoppe, Koen Veermans, Bram de Wever**
19:30 - 22:00	Dinner at Stadtpark Gastronomie

Friday, 24th of August 2012

Time	
09:00 - 09:45	Session 6 - Work in Progress Papers
	Miao Yongwu, Jan Engler, Christopher Krüger, Adam Giemza, Stefan Weinbrenner, H. Ulrich Hoppe A Domain-specific and Lightweight Process-oriented Scaffolding Agent
	Daniel Spikol, Nuno Otero Investigating how to support conceptualization of science with new media tools for students
09:45 - 10:00	*Break*
10:00 - 11:30	Keynote **Janice Gobert**
11:30 – 11:45	*Break*
11:45 - 12:30	Session 7 - Simulations II
	Sebastian Timpe, Astrid Wichmann The role of interactivity in inquiry learning using simulations
	Katherine Perkins, Emily Moore PhET interactive simulations: Using implicit scaffolding to support productive inquiry learning
12:30 - 13:30	*Lunch*
13:30 - 14:30	Business Meeting
14:30	End of Conference

Proceedings

Wednesday, 22nd of August 2012
Time: 14:30 – 15:25

Interactive Demo

Science Assistments: assessing and assisting students' scientific inquiry

Janice Gobert
Ermal Toto
The Science Assistments Team

We present our computer-based learning environment, Science Assistments (http://www.scienceassistments.org; NSF-DRL # 0733286, # # 1008649; NSF-DGE #0742503; U.S. Dept of Ed. # R305A090170, #R305A120778), for Physics, Life Science, and Earth Science that assesses and scaffolds middle school students' scientific process skills, namely, hypothesis-generation, design of experiments, data collection, data interpretation, and warranting claims with evidence. In our project we have developed 25+ microworlds, an assessment reporting system, and a suite of inquiry tools to support students' inquiry in terms of the five skills mentioned above. Together, the logging functionality and the inquiry tools provide the basis for automated web based assessment and adaptive scaffolding of students' inquiry in real time on the basis of knowledge-engineering and educational data mining (EDM). Our infrastructure is flexible, easy to deploy, and can be implemented in, but not limited to, existing course management systems such as Assistments and Moodle. By reacting to students' inquiry strategies in real time, we hypothesize that it will be possible to positively affect both students' science process skills, shown by more goal directed inquiry and more systematic experimentation, measured through log files of detailed student actions, system evaluations of student actions based on EDM and knowledge engineering rules, as well as students' content learning, as measured by pre-post test gains. We are testing our adaptive scaffolding in a series of randomized controlled studies in our partner schools; the demographics of these students represent a wide range of SES and ethnic backgrounds, and thus, our data should generalize well. Goal outcomes include empirical data regarding the efficacy of our system at improving students' science learning, namely, inquiry skills and content learning, across several dependent measures in each content domain.

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SimSketch & GearSketch: Sketch-based modelling for early science education

In this interactive demo, we will present two modelling and drawing applications - SimSketch & GearSketch, which exemplarily demonstrate our approaches to sketch-based learning and modelling in early (science) education. Since drawings and sketches denote are very basic and fundamental way of sharing ideas, of externalising and disambiguating mental models and conceptual understanding, they constitute a convenient tool in learning. Even more, creating and understanding drawings is a skill which is trained and used in very early education, and since drawings are free of syntactical constraints, they can be used in numerous domains and school subjects. Today, modern technology (tablet PCs, touchscreens, pen-based input devices) paved the way to go beyond the possibilities (and limitations) of pen & paper - to keep the feeling and practice but add computational components and features. The presented tools go further than simple drawing and sketching on a computer - SimSketch and GearSketch enable the learner to create drawings "that talk back": The drawing software is able to give immediate feedback on the learner's sketch by creating an executable model from the drawing which can be simulated - the drawing becomes "alive" and confronts the learner with the results and consequences of his externalised mental model.

Wouter van Joolingen
Lars Bollen
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Wednesday, 22nd of August 2012
Time: 14:30 – 15:25

Interactive Demo

Virtual Performance Assessments

Jody Clarke-Midura

The Virtual Performance Assessment Project, also known as VPA, is a research project at the Harvard Graduate School of Education (vpa.gse.harvard.edu). In this project, we are studying the feasibility of using Virtual Performance Assessments to measure middle grade students' science inquiry skills and practices (US grades 7-8). Such process-oriented skills are difficult to measure with multiple-choice and open-response tests. Specifically, we are interested in students' ability to investigate a problem, gather data, and then build a claim using evidence.

The virtual performance assessments are designed in the Unity game development engine (http://unity3d.com). The immersive nature of the three-dimensional (3D) environment allows for the creation and measurement of contextualized performances. Students take on the identify of an avatar (see images below) and have the ability to walk around the environment, make observations, gather data, and solve a scientific problem in a context. In one assessment, students have to investigate why a frog has 6 legs. In a second, they have to investigate why the bees are disappearing.

Students work individually on the assessments. They access the assessments via a web browser and work through the problem in 45 minutes or less. On the back-end, we capture students' actions and use them to build arguments for what students know and understand about building claims and using data as evidence. The goal of the research is to provide the field with working examples of reliable and valid technology-based performance assessments linked to frameworks and standards for science content and inquiry processes. This research is funded by the Institute of Education Sciences and the Bill & Melinda Gates Foundation.

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Using metacognitive scaffolding to improve learning from guided invention activities

Natasha Holmes
Ido Roll
James Day
Doug Bonn

Invention activities are inquiry-learning activities that ask students to invent a solution to a problem before being taught the expert solution. The combination of invention activities and direct instruction has been shown to lead to better student learning and performance on transfer tasks, as compared to direct instruction alone. We previously found that guiding students through specific invention strategies (such as exploratory analysis) helps them notice more features of the data and reason at a deeper level. This research further investigates the effect of guidance by expanding the treatment across a four-month term, and using computer-based methods to deliver the tasks. A two-group, pre-post experimental study with 128 participants was carried out to evaluate the effect of fading guidance for specific inquiry strategies on learning of domain-level knowledge and inquiry skills. Participants, first-year physics students in a leading university, were randomly placed into one of two groups: a Control condition, and a Faded-Guidance condition. All students worked on invention activities in statistics and data analysis, where they were asked to invent and apply a mathematical method using data provided. Unlike students in the Control condition, students in the Faded-Guidance condition also received scaffolding of inquiry behaviours such as self-explanations, exploratory analysis, and evaluation of outcomes. The levels of this scaffolding were faded across five invention activities, such that the final invention activity was provided with the same level of guidance as in the Control condition. While no effect was found between groups on conceptual and procedural knowledge, Faded-Guidance students outperformed Control students on transfer items that required deeper reasoning. This effect was only observed for topics that were learned when the Faded-Guidance condition received high levels of support.

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Keywords: Invention activity, inquiry-learning, computer-based activities, metacognitive scaffolding

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Should invention activities in a delayed instruction setting be guided?

Katharina Westermann
Nikol Rummel

The work on Productive Failure (PF, Kapur, 2009) suggests that students can benefit from inventing solutions to mathematical problems that require application of yet unknown concepts in a delayed instruction setting. Kapur could show that students in a PF condition learnt more than students who received Direct Instruction (DI) right away. Process data of the PF condition showed that students invented a diversity of solutions, but they did not develop a canonical solution. Thus, a subsequent instruction phase was necessary to lead students towards the canonical solution. Based on the literature on guided discovery learning one could assume that guidance during the problem-solving phase might further increase the learning outcome. Moreover, in Kapur's study students in the DI condition received a different form of instruction than students in the PF condition: The teacher directly presented the canonical solution, rather than building on typical student-generated solutions and intuitive ideas. In our quasi-experimental study, we therefore aimed to shed light on both questions: Does guidance increase the effectiveness of the problem-solving phase for learning? And what is the impact of building instruction on typical student-generated solutions and intuitive ideas? To answer both questions, we varied the form of instruction in two DI conditions (a regular DI condition and a DI-S condition where instruction built on typical intuitive ideas) and the amount of guidance in two PF conditions (a regular PF condition and a PF+ conditions with additional cognitive guidance). DI-S, PF and PF+ did not differ regarding their learning outcomes, but outperformed DI. Thus, it seems important to include students-generated solutions and intuitive ideas in the instruction. The cognitive guidance during the problem-solving phase in the PF+ condition does not seem to be necessary. This might be due to the structure provided in the subsequent instruction phase.

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Keywords: Intuitive ideas, prior knowledge, inventing, productive failure, guidance

Subject – context – tools: Emerging connections – the role of ICT in foreign language pedagogy

Heinz Kreutz
Katharina Franke

Playing a top-down catalytic role, Monash University has recently introduced a wide range of technological tools (e.g. http://www.monash.edu.au/eeducation/metl/) and systems aimed at assisting in the delivery of a more collaborative, inquiry-based pedagogy. Drawing a link between the challenges of technology-supported pedagogy and those of the foreign language classroom, our presentation will explore the relationship between information and communication technology (ICT), foreign language pedagogy and the notion of affordances as an integral component of classroom success or failure. Special attention will be given to the role of learning strategies that espouse productive failure (Krashen's interlanguage developmental errors) and inquiry-based, foreign language learning in a German as a foreign language environment. The presentation will utilise three sets of data, based on a 2011 survey yielding 97 responses from 72 undergraduate language and linguistics students, results from a qualitative survey from 30 advanced German language and linguistics students, participant-observational data from the German foreign language and linguistics classroom, including jointly produced learner text samples. Set 1 sets out to illuminate the student voice, Set 2 elicits attitudinal responses from 30 students about their experience with a set of ICT-based learning tools, Set 3 constitutes participant observations of classroom learner interactions and collaborative efforts. The hypothesis that productive failure (Krashen's developmental interlanguage errors), can be employed as a meaningful strategy in the development of second language discourse competence is emerging as a tenable proposition. Joint text production in learner-language German, where deixis, cataphoric and anaphoric devices constitute surface realisations of collaborative inquiry in a target language environment, deliver a fertile environment for our exploration of technology-enhanced foreign language learning.

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Keywords: Technology-supported foreign language pedagogy, affordances, productive failure, inquiry based learning in foreing languae pedagogy

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Characterizing the incorporation of bioinformatics into high school biotechnology curricula through a scientifically authentic learning environment

Yossy Machluf
Hadas Gelbart
Anat Yarden

Bringing contemporary and authentic scientific practices through inquiry activities to high-school science education holds great benefits and challenges. A web-based bioinformatics learning environment (BLE) that is aimed at introducing bioinformatics into a high-school biotechnology curriculum through engaging learners in scientifically authentic inquiry activities served as a context for this study. We report on the analysis of 12th grade students' learning outcomes and attitudes towards bioinformatics learning following enactment of inquiry activities from the BLE. To this end, we analyzed of students' answers to questions embedded in the BLE, pre- and post-activity questionnaires, and interviews with students. Our quantitative and qualitative analyses revealed that while practicing firsthand the BLE inquiry activities students gained various types of scientific knowledge and skills and exhibited positive attitudes towards the subject and its' instruction. In general, BLE activities are in line with students' abilities. Yet, questions which are open-ended, associated with the higher cognitive process dimensions, require the use of a biological approach, the use of declarative or strategic knowledge, are significantly more challenging. Students not only gained content knowledge in biology and bioinformatics, but also acquired procedural understanding and skills in using bioinformatics tools, and strategic knowledge for solving scientific problems. Most students appropriated the bioinformatics approach, through adopting authentic scientific research practices, and through implementing and extending bioinformatics use to the "traditional" biotechnology curriculum. This study shed light on how high-school students perceive and engage in scientifically authentic inquiry activities.

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Keywords: Authenticity, scientific practices, domain-specific knowledge, inquiry, learning environment

Scaffolding students' use of learner-generated content during an inquiry-based science project

Ard Lazonder
Alieke van Dijk

Having students inspect and use each other's work is a relatively new and promising way to advance inquiry-based science learning. Previous research has nevertheless shown that additional support is needed for students to take full advantage of the products created by their peers. The present study investigated whether scaffolding through a worksheet could bring about the desired effect. This worksheet outlined the steps in searching for information in peer-created concept maps, and contained specific directions on how the quality of this information should be assessed. The effectiveness of the worksheet was investigated by comparing the performance of 43 high school students engaged in an inquiry-based science project. Main results showed that students who received the worksheet (n = 20) developed a more differentiated and interconnected conceptual understanding than students who did not (n = 23). However, the worksheet also put additional demands on students' self-regulatory abilities, and hence seems to require some practice or regulatory support to reach its full potential.

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Keywords: Scaffolding, concept maps, constructionism, learning objects

Transforming a problem space: planning behavior through inquiry learning or instruction? The digital zoo-game approach

David Tobinski
Annemarie Fritz-Stratmann
Walter Hussy

Problem solving abilities are seen as core-competencies and nearly every school subject keeps them in focus (Klieme et al. 2005). But leading a learner to those abilities poses a major question: taking the guided or the unguided path? Following the research question of comparing learning effects from inquiry learning and instruction on problem solving abilities, a new problem solving paradigm had to be found. The authors used a standardized diagnostic tool for interpolation problem solving, named as ZOO GAME. Before expanding the ZOO GAME approach for an inquiry learning phase, it had to be converted from an analog test instrument into a computer-based assessment test (De Jong & Van Joolingen, 1998). Within the ZOO GAME approach the participant has to transform a well-defined problem from a beginning state to a goal state by using a special set of complex rules (Fritz & Hussy, 2000). In a further step the instructional phase has been replaced by an inquiry learning scenario. This design of different pre-phases leads to a comparable planning phase, in which central indices measure the effectiveness and efficiency of interpolation problem solving. Two studies (N = 138 and N = 177) have been arranged in eleven primary schools of North-Rhine Westphalia. Comparing the dispersions of planning span between the learning groups a high significant difference is given, $\chi 2$ (4, n = 138) = 26.01, $p < .001$ with an effect power of Eta2 = .43. Under the «exploring» condition the numbers of best planners as well as the numbers of worst planners double. It becomes apparent that inquiry learning leads to better results in planning behavior concerning the effectiveness, but it is also widening the division between good and bad planners. These facts lead to the assumption that inquiry learning generates a different quality of knowledge.

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Keywords: Exploration, problem space, problem solving, planning

Inclusion of perceptually abstract elements in a computer-based educational simulation in elementary school context: Reward or hazard?

Tomi Jaakkola
Koen Veermans

Simulations allow students to investigate domain principles by setting up experiments and controlling parameters. An important design consideration is determining how concrete simulation elements should be. A simulation with perceptually concrete elements is easier to understand whereas abstract elements may enhance transfer.
This paper describes two studies that attempted to replicate findings of Goldstone and Son (2005) in a different domain and with younger children using the two extreme conditions from the original study, concrete and concreteness fading. In the present studies students constructed and studied electrical circuits in two different simulation environments. In the concrete condition simulation elements remained perceptually concrete (circuits with bulbs) throughout the experimentation, whereas in the fading condition the elements switched from concrete (bulbs) to abstract (resistors) during the experimentation.
The results of Study I (N=52) showed that the concrete condition outperformed the fading condition on the post-test. It appeared that the abstract elements made the inquiry process more difficult, and that learners in the fading condition had difficulty connecting their learning to bulb related test items. Therefore in Study II it was decided to delay fading slightly in the fading condition. The results of Study II (N=125) show that the delayed fading had a considerable impact on students' learning and transfer as no differences were found between conditions in learning outcomes.
The results of the two studies show that inclusion of perceptually abstract items in a simulation environment is a sensitive process. The results also indicate that the effectiveness of fading may vary across domains and age groups: even though the effectiveness of fading improved considerably from Study I to II, we were unable to reproduce Goldstone and Son's findings, as fading did not provide notable benefits compared to the use of constantly concrete elements.

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Keywords: Inquiry, electricity, elementary school, science, simulation, physical fidelity

Student attributes, affective states, and engagement in science inquiry microworlds

Arnon Hershkovitz
Ryan S.J.d Baker
Janice Gobert
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Michael Wixon

In recent years, research has revealed relationships between student attributes (e.g., learning orientation, grit), affective states (e.g., boredom, frustration), and engaged and disengaged behaviors (e.g., on-task conversation, gaming the system) for students using computer-based learning environments. However, past studies on these issues have typically focused only on small subsets of these constructs. A more comprehensive approach may have the benefit of helping us understand the full context of how student attributes lead to affect and engagement, and how these factors interact. To this end, we examine the relationships between variables measuring student attributes, affect, and engagement. We study these issues in the contexts of middle school students learning from computer-based science inquiry microworlds. We replicate previous relationships also seen in intelligent tutoring systems, i.e., negative correlations between grit and gaming the system. At the same time, our approach finds relationships not studied in prior research, including positive correlations between frustration and on-task collaboration. These findings shed light on how student individual differences influence affect and engagement during learning, which in turn, can contribute to developing a more comprehensive model of these relationships.

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Thinking with drawings - Sketch-based modelling in early science education

Self-constructed external representations can positively affect the course and type of reasoning for various reasons, e.g. by proving a ground for (self-) explanations, by helping to disambiguate learners' mental models of phenomena or by reducing working memory load. Especially in early education, drawings and sketches can be beneficial, since they make use of known and established techniques and do not impose a formal syntax or modelling language. By making use of computer-supported, pen-based input devices, applying sketches in educational contexts can be brought to a higher level, e.g. by supporting the learner with awareness information and feedback, by enabling collaborative experiences, and by literally bringing a learner-created drawing to life. In this contribution, we outline our efforts to utilise learner-created drawings in modelling activities in early science education. We will describe approaches for using sketches in educational contexts called SimSketch, an application to create multi-agent simulations based on drawings. The main purpose of SimSketch is to assist learners in creating executable simulations of scientific topics, using an informal representation based on drawings.

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Keywords: External representations, simulation, modelling, sketch recognition, exercise selection

Combining traditional instruction and simulation-based inquiry learning in secondary vocational technical education: Effects on understanding

Bas Kollöffel
Ton de Jong

Traditionally, engineering curricula about electrical circuits use direct instruction and hands-on lessons, which are effective approaches for teaching students terms and definitions, the procedural use of formulas, and the capacity to build circuits. However, students often lack conceptual understanding. The aim of this study was to find out how the acquisition of conceptual understanding can be facilitated. It was hypothesized that adding an extra instructional method in the form of simulation-based inquiry learning would be more effective than relying on the traditional instruction only. Intermediate level vocational engineering training students were randomly assigned to one of two conditions in a quasi-experimental study. In one condition the traditional curriculum was enriched with additional (computer-based) practice in the other, experimental condition the traditional curriculum was enriched with simulation-based inquiry learning. The results showed that students in the experimental condition scored significantly higher on conceptual understanding (Cohen's d = 0.65) and on procedural knowledge (d = 0.76). . Students in this condition scored in particular higher on solving complex problems (d = 1.19). This was true for both complex conceptual and complex procedural problems. It is concluded that enriching traditional instruction with simulation-based inquiry learning enhances conceptual understanding. The observation that students in this condition also obtained more procedural knowledge than students in the traditional condition gives support for the idea that conceptual and procedural knowledge develop in an iterative fashion.

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Keywords: Simulation-based learning, conceptual understanding, electricity instruction, secondary vocational education

Keynote

Thursday, 23rd of August 2012
11:00 - 12:30

Supporting inquiry and modeling with interactive drawings

Creating models is at the heart of any scientific endeavor and therefore should have a place in science curricula. However, creating computer-based models faces resistance in early science education because of the difficulty to create the formal representations required by computational systems. In this keynote I will present SimSketch, an approach to integrate the creation of drawing into the process of inquiry and modeling. In SimSketch, drawings are used by learners to represent their ideas about phenomena they investigate. Assisted by the learner, SimSketch converts these drawings to computational models, that generate animations that behave according to the learner's specification. Children in age ranging from 8 until 15 have used SimSketch in several domains: astronomy, traffic and biology. I will report on the results of these studies in terms of the effect on domain knowledge as well as scientific skills and attitudes.

Keywords: Modeling, scientific literacy, simulation, drawing

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Cognitive group awareness support for collaborative discovery learning

Alexander Scholvien
Daniel Bodemer

When learners encounter collaborative multimedia learning scenarios they face certain challenges that can constrain successful learning. Providing knowledge-related information showed to support learners mastering these requirements with regard to collaborative learning with multiple external representations. However, there is no comparable systematic evidence regarding the combination of collaborative learning and scientific discovery learning. This study was designed to close this gap and to investigate whether cognitive group awareness support fosters meaningful collaboration and improves collaborative discovery learning.
Learning dyads were compared in two experimental groups (N = 72), which differed in the level of cognitive group awareness support during collaboration. While learners in one experimental group were provided with a hypothesis tool that contained each learner's assumptions (group awareness support), learning partners in the other group could only see their own assumptions.
Results show that supporting cognitive group awareness by providing knowledge-related partner information improves learning, task performance and knowledge-related conflict resolution. Furthermore, preliminary analyses indicate that group awareness influences communication behaviour: learning dyads that were provided with their learning partners' assumptions spend less effort in knowledge-related grounding activities but are more often engaged in elaborative discussions.

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Keywords: Scientific discovery learning, collaborative learning, group awareness

Effects of small group collaboration scripts and classroom scripts on online search competence during a biology inquiry unit

Ingo Kollar
Christof Wecker
Sybille Langer
Frank Fischer

Online search competence may be regarded as an important component of scientific literacy. A promising approach to support learners in acquiring online search competence is web-based inquiry learning. However, as previous research has repeatedly demonstrated, inquiry learning needs to be scaffolded in order to successfully support students' learning. In this contribution, we look at the effects of classroom scripts (i.e. instructional interventions that distribute learning activities over different social planes of the classroom) and small-group collaboration scripts (i.e. instructional interventions that distribute learning activities among the learners of a small group). In a quasi-experimental 2x2 factorial design, we examined to what extent a small-group collaboration script (present vs. not present), two versions of a classroom script (version A: all online search activities located on the small group level vs. version B: online search activities located on the small group and the plenary level) and their different combinations may foster high-school students' acquisition of online search competence in a web-based inquiry curriculum unit on Genetic Engineering. Results indicate that employing a classroom script that alternates search activities between the small group and the plenary level can make further structuring on the small-group level (through a small-group collaboration script) obsolete. Adding a small group collaboration script to the alternating classroom script did not lead to further improvement, possibly because the modelling phases that were part of that classroom script reduced time for actually performing the proposed search strategy. However, if all search activities were to be conducted on the small group level, the small group collaboration script had positive effects. This study demonstrates that the effectiveness of inquiry learning can be improved by scaffolding, especially when the used scaffold includes activities on the plenary level.

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Keywords: Online search competence, classroom scripts, collaboration scripts

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Fostering online search competence in an inquiry learning curriculum: Effects of continuous and faded collaboration scripts

Christof Wecker
Ingo Kollar
Frank Fischer

An important goal of science education is to prepare learners to participate in debates about socioscientific issues. An important competence in this respect is online search competence. Computer-supported collaborative inquiry learning provides an appropriate context to foster this educational goal. However, learners' spontaneous collaboration is often suboptimal. Prior laboratory research has shown that collaboration scripts can stimulate productive interaction and thereby positively affect learning outcomes, and a faded script may have even stronger effects. We investigated whether continuous and faded collaboration scripts positively affect the learners' performance of the strategy suggested by the script and thereby foster online search competence in an inquiry learning context. In a curriculum unit about Genetic Engineering with three inquiry cycles involving one online search phase each, three experimental conditions were implemented: No script, continuous script, and faded script. The performance of the strategy was measured based on recordings of learners' utterances and activities on the computer by means of screen-audio-capturing software. Learners' online search competence was measured in individual pretests and posttests. Both the continuous and the faded script had positive effects on the performance of the strategy and online search competence compared to unsupported collaboration, but these two conditions did not differ from each other in these respects. Learners' performance of the strategy further predicted the development of online search competence. The findings indicate that collaboration scripts can be effective means to foster online search competence in an inquiry learning context and that the main learning mechanism is by means of performing the strategy rather than observing one's learning partner performing it or by mere exposure to script prompts.

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Keywords: Collaboration scripts, fading, online search competence, strategy performance

Scripting collaboration in web-based collaborative inquiry in face-to-face classroom settings

Annelies Raes
Tammy Schellens
Bram De Wever

The aim of this study is to investigate the effects of providing a collaboration script on the quality of collaboration and on students' learning performances during and after Web-based Inquiry Learning through a quasi-experimental design. A web-based collaborative inquiry project was implemented in 12 secondary school classes involving 206 students. Six classes were provided with a collaboration script embedded in the Web-based project, six classes were not provided with this collaboration script. A mixed-methods approach is used in which both quantitative and qualitative sources of evidence are triangulated. The quantitative part of the study focuses on the multilevel analyses performed on the total dataset to model and predict students' learning achievement and students' self-reported quality of their collaboration processes. The qualitative part focuses on the in-depth analyses of the observed quality of the collaborative processes based on a subset of the dataset (32 dyads). The collaboration script implemented in this study is based on the framework of Kobbe et al. (2007) and particularly focuses on roles and the mechanisms of task distribution and sequencing. The assessment of the process of collaboration is based on the rating scheme presented by Meier, Spada and Rummel (2007). The rating scheme takes into account nine dimensions of collaboration, i.e. sustaining mutual understanding, dialogue management, information pooling, reaching consensus, task division, time management, technical coordination, reciprocal interaction, and individual task orientation. Preliminary analyses reveal some significant effects of a collaboration script on the self-assessed quality of collaboration. Yet, the collaboration script doesn't result in better group performances and individual learning outcomes. The results of the qualitative collaborative process analyses will help to increase our understanding of when and why a collaboration script is helpful.

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Keywords: Collaboration, scripting, mixed-methods, web-based inquiry

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Thursday, 23rd of August 2012
15:30 - 17:30

Panel

Towards a shared grammar: Logging and analyzing interactions across a variety of inquiry environments

Ido Roll
Jody Clarke-Midura

Panelists:
Kathy Perkins
H. Ulrich Hoppe
Koen Veermans
Bram de Wever

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Inquiry learning environments offer an exciting opportunity to study learning at finer grain-sizes and over longer periods of time than previously possible. Tracing students' learning trajectories action-by-action allows the system to adapt to individual students characteristics (e.g., Dragon et al., 2006; Luckin & du Boulay, 1999; Manlove et al., 2007; Roll et al., 2010; Veermans et al., 2000; Weinbrenner et al., 2010) while documenting how students learn science over time (Mulder et al., 2009; Sao-Pedro et al., 2011). Yet, so far, most analysis of students' learning behaviour is done within individual systems. The data systems collect is unique to each system, and researchers operationalize their own construct in different ways. Paraphrasing a common saying, "inquiry environments are like toothbrushes: everyone has one and nobody uses anyone else's."

Our field lacks common formats and tools for data logging and analysis. While progress towards shared data repositories and toolboxes was made in coached problem-solving environments (i.e., PSLC DataShop; Koedinger et al., in press), to the best of our knowledge, this is not the case with inquiry environments. One reason may be the complex and rich nature of interaction in inquiry environments.

The goal of this suggested symposium is to begin conceptualizing a shared format for data collection in inquiry environments. Specifically, this participatory session will address the following questions:

a. What information do you collect about your students' learning process? (video, audio, log files, screen capture, chat transcripts, etc). Specifically, what information is included in the log files? Please show an example of a couple of actions in the system and how they appear in your logs.
b. What behaviours can you infer from this data?
c. What information are you missing, and how does it limit your ability to learn about students' learning?
d. Can you identify bits of information that are common across inquiry environments? What are the key properties of a unified format for logging? (basic information, unit of analysis, etc).
e. Should we thrive to establish standards for logging from inquiry environments? If standards for logging data could be identified, how would you benefit from these sources?

Last, we will identify additional steps towards the goal of shared data across inquiry environments.

Keywords: Educational data mining, learning analytics, inquiry learning, log files

A Domain-specific and Lightweight Process-oriented Scaffolding Agent

In recent years many efforts have been made to provide computational metacognitive scaffolding. However, it is still challenging to develop and integrate computational metacognitive scaffolding mechanisms, which not only guides students to conduct scientific inquiry processes in a systematic way, but also helps them to monitor, plan, and evaluate inquiry activities. We argue that a domain-generic and lightweight process-oriented scaffolding agent (POSA) is technically feasible to implement by exploiting process modeling technologies, and is useful for the students who work with a flexible, open-end inquiry-based learning environment.

In this paper we present our approach to the development of a domain-generic and lightweight POSA. Based on the theories of metacognition and inquiry-based learning, we designed the POSA to support inquiry-based learning processes in complex domains centered on emerging learning objects (ELOs). The POSA consists of a POSA core and an Agenda tool. The POSA core helps students to manage metacognitive knowledge about task, strategy and learner and generates process-oriented metacognitive scaffolding. The Agenda tool provides a user interface for students to receive appropriate prompts and awareness information on time or on demand, and to monitor work progresses and to reflect on and possibly re-plan their learning processes. So far a prototype of the POSA has been implemented and integrated with SCY learning environment, called SCY-Lab. In order to have a better understanding of the POSA, we use an example, called "Healthy Pizza Mission", to explain the implementation and usage of the POSA.

Furthermore, we report a pilot study to investigate the learners' acceptance of the POSA based on the Technology Acceptance Model (TAM), a widely used general-purpose instrument for measuring users' attitude towards a particular technology or tool. The results reveal that most of participants found the agent generally useful and easy to use for supporting a flexible, open-end inquiry learning process.

Keywords: Inquiry learning process, metacognition, process-oriented scaffolding agent, technology acceptance model

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Investigating how to support conceptualization of science with new media tools for students

Daniel Spikol
Nuno Otero

This paper presents an exploratory study that investigates how learners' media creation skills impact on their ability to take advantage of inquiry based learning approaches and externalize/share their understandings of complex scientific concepts and problems. This study is part of an ongoing research project focused on making mobile science inquiries in ecology more accessible and effective for high school students. The focus of this paper relates to our efforts in trying to better understand how to design learning activities that introduce digital skills to the science classroom. The intervention consisted of 4 sessions with the students over 5 weeks in the late spring of 2011. A pre and post explorative survey focused on three distinct issues: (a) how students can conceptualize science using different media along with digital material created by the students (b) how the students perceived their small group interactions and group work in general and (c) how the students perceive the classroom activities related to the learning tasks referred to in this study. Preliminary findings suggest that there is a need to improve new media creation skills and tie them to the different steps involved in inquiry based learning activities. Such approaches explore how to leverage learners' motivation towards the creation of exciting learning objects that can be co-created and shared.

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Keywords:

Keynote

Friday, 24th of August 2012
10:00 – 11:30

Learning with scientific simulations: Affordances for performance assessment and adaptive intelligent tutoring of scientific inquiry skills

Janice Gobert

Our computer-based learning and assessment environment, Science Assistments (http://www.scienceassistments.org), for Physics, Life Science, and Earth Science supports middle school students' scientific process skills, namely, generating hypotheses, , designing and conducting experiments, data interpretation, warranting claims with data, and communicating findings. Leveraging from the logging functionality of our infrastructure and our inquiry tools, we apply educational data mining and knowledge engineering algorithms to analyze students' log files in real time in order to provide assessment reports to teachers on students' inquiry skills, as well as to provide adaptive intelligent tutoring to students via our pedagogical agent, Rex. By reacting to students' inquiry learning in real time, we hypothesize that students' science process skills are positively impacted. I will present data from several classroom studies and discuss the specific affordances of technology-based microworlds for both performance assessment of inquiry skills as well as intelligent tutoring of scientific inquiry in real time.

Keywords: Science inquiry, performance assessment, intelligent tutoring

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The role of interactivity in inquiry learning using simulations

Sebastian Timpe
Astrid Wichmann

An important feature that separates inquiry learning from other approaches is to actively involve learners in knowledge construction by utilizing tools and methods that are commonly used by scientists. Active involvement is assumed to lead to deeper processing, motivational gains but also increased mental effort (Nerdel, 2003). Students (N=118) from four chemistry classes conducted simulation-based scientific experiments using Molecular Workbench (Xie & Tinker, 2006). The level of interactivity was varied in three conditions: (1) preparing-interactive, (2) interactive and (3) non-interactive. As expected, students in both interactive conditions (1) and (2) were more effective than students in the non-interactive condition (3) with respect to intuitive knowledge. Students in the preparing-interactive condition were descriptively slightly better than in the interactive condition, but this difference did not reach statistical significance. Results indicate that the level of interactivity does indeed have an effect on learning at least concerning intuitive knowledge. Increased interactivity level lead to significantly higher motivational gains for the interactive condition, but not for the preparing-interactive condition. Descriptively, mental effort was the highest for the preparing-interactive condition and the lowest for the non-interactive condition. However these differences did not reach statistical significance. These findings are in line with the notion of “desirable difficulty” (Bjork & Linn, 2006) that perceived increase of mental effort may lead to desirable outcome.

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Keywords: Intuitive knowledge, simulation-based learning, interactivity

PhET interactive simulations: Using implicit scaffolding to support productive inquiry learning

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The PhET Interactive Simulations project at University of Colorado Boulder has developed over 115 simulations for teaching and learning science and math. In addition to addressing specific content learning goals, the simulation designs aim to support inquiry learning – for example, supporting students to engage in productive, scientist-like exploration, to take ownership of their learning, and to generate their own knowledge. We present the use of implicit scaffolding in simulations, using PhET's 'Build a Molecule' simulation as an example. Implicit scaffolding – in contrast to most examples of explicit scaffolding – aims to retain a student's sense of autonomy while creating an environment in which multiple, natural, investigative pathways and questions lead toward the desired knowledge acquisition. Successful designs tend to leverage what students know (e.g. buckets hold things, scissors cut), to cue important factors through intuitive designs (e.g. cuing attention to chemical formulas through molecule collection boxes or to key parameters by using sliders), to tap into natural curiosities (e.g. spark "what if?" or "why?" questions), and to support building of knowledge (e.g. using tabs to scaffold complexity). We present evidence of effective implicit scaffolding from 8 interviews of middle school students using PhET's 'Build a Molecule' simulation. We demonstrate that this approach to scaffolding allows students to engage in exploration that is both student-driven and productive for student learning of content, reporting significant learning gains when 'Build a Molecule' is used in 5th grade classrooms. With implicit scaffolding provided by simulations, teachers can reconsider the amount and type of external guidance needed in classroom activities, allowing for the inclusion of more open-ended questions and less explicit directions.

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