

Proceedings
International Workshop

Science education and guidance in schools: the way forward

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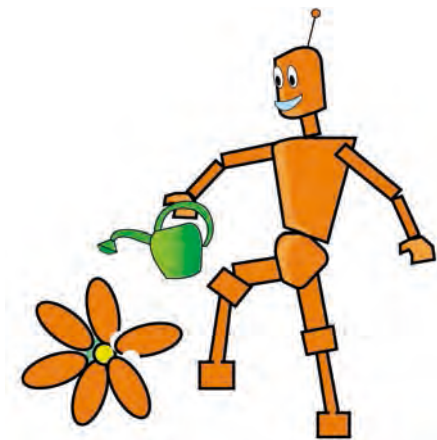
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ACARISS

*Increasing the knowledge on environmental issues and pollution risks
involving school with experimental activities*



Edizioni ETS

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WELCOME ADDRESS

The direct observation of scientific phenomena and their experimentation and discussion in classroom rather than the mere transmission of theoretical knowledge are powerful didactic tools for Science Education. Students can be, in fact, challenged with the object of the study, actively involved in asking questions and formulating hypotheses that can be tested through experiments in classroom. We successfully tested these concepts and approaches in the ACARISS project (www.acariss.it – Italian Acronym for Increasing the knowledge on environment and pollution risks involving schools with experimental activities; funded by Tuscany Region) which aimed to create links between Scientific community and Schools and to make Science teaching more attractive for students by giving tools and methods to teachers for developing scientific themes in classroom.

To present the ACARISS experiences, to a wider audience, an International workshop, was organized in Florence. Its title, “SCIENCE EDUCATION AND GUIDANCE IN SCHOOLS: THE WAY FORWARD” reflects the aims to promote a scientific debate on science learning and teaching methodologies in schools but also on the use of ICT for scientific learning in the area of environmental sciences, life sciences and applied robotics. We thought this workshop could facilitate networking and future collaborative projects.

The enthusiastic contribution from many academics and researcher colleagues all over the world, witnessed by these proceedings, went much beyond our expectations

Hoping that this book will be useful to all those engaged in the teaching of Science we address a particular thank to all of them that contributed to the success of “SCIENCE EDUCATION AND GUIDANCE IN SCHOOLS: THE WAY FORWARD” workshop, and to the Tuscan Regional Government that provided the means to make the Project and the Workshop possible.

*Antonio Raschi
Annamaria Di Fabio
Luca Sebastiani*

There are two keywords for our future: youth and science.

Linking these words is a strategic objective, reachable only through new and original methodologies of science information which go over the current academic vision of science, closed to non-experts, and beyond the traditional methods of science teaching. Indeed, the scientific community is often felt as disconnected from the civil society and the labour market, while the knowledge of environment and the research of solutions to environmental problems are real issues whose caring is nowadays our common responsibility. It is therefore crucial to raise people awareness on environmental issues and on science potentiality to solve them. This will also enhance the capacity of the next generations to take their own decisions and actions in professional and personal life, on the base of a conscious and proved knowledge.

Within the Acariss project, it has been confirmed that scientific education in a new and original way, alternative to frontal lessons, is possible and effective. Inquiry Based Learning is an effective methodology to attract students to science and transmit a scientific culture made of observations, hypothesis, models, explanation and concept acquisition. Moreover, it has been demonstrated that it raised up youth sensitiveness toward the environment, curiosity toward the scientific thematics and their career choices.

Initiated by scientists of the Institute of Biometeorology-CNR in Florence and Scuola Superiore Sant'Anna in Pisa, with the support on science communication and evaluation methodology by the Department of Science of Education and Psychology of the University of Florence, Acariss attempted to bring authentic science experiments into the classrooms of the schools of Tuscany Region, directly inspired by field and laboratory research, with the broader perspective of building sustainable societies. ACARISS project reached about 40 schools, scattered in the whole regional territory, and offered didactic materials and scientific tools to teachers, contributing to the teaching quality.

Nevertheless, Acariss project is not an isolated example of good practice in science teaching, as demonstrated by the contributions presented at the international Workshop, "Science Education and guidance in schools: the way forward", and included in this volume.

The Workshop was organized at the conclusion of the Project, to present the result and to discuss them with a wider audience, and we were proud to host in our city of Florence, the active group of participants coming from a wide range of European and extra-European countries, surely attracted by Florence, as capital of art and science, but also intrigued by the workshop thematics. I am sure that the workshop gave participants large opportunities for exchanges and opened to future collaborations with new inputs of experimentation.

The presentations and posters covered a wide range of themes on science didactic and science communication: study cases with practical examples inside the classrooms, methodologies for the assessment of their effectiveness, use of new technologies in didactic and environmental knowledge.

We are confident that this publication will help to keep alive and fruitful the willingness of authors to interact and that new collaborations will contribute to build a common path toward a fascinating, creative and useful science for our next generations.

Stella Targetti

(Vice Presidente Regione Toscana e Assessore alla Ricerca)



The Institute of Life Sciences, recently formed by the merging of Agricultural Sciences and Biomedical Science, two historical and strategic areas present at Scuola Superiore Sant'Anna, has the ambition to be home of researchers working on a wide spectrum of topics dealing with living organisms, from molecules to ecological organizations. This goal can only be met by applying interdisciplinary and multidisciplinary approaches, the type of approaches that must characterize a modern education in science. In the proceeding of Science education and guidance in schools: the way forward, you will appreciate a number of innovative examples in which this topic is being addressed. The recently launched European Union agenda Horizon 2020 states the ambitious goal to overcome the current economic crisis by creating a smarter, greener economy, whose achievement strictly derives from research and innovation. In fact Europe needs more scientists and more people skilled in science and technology in order to compete in the global arena. However, in the long and winding road of human cultural evolution the conflict between science, superstition and prejudice has been a constant. Even now in all modern and advanced societies there is an anti-scientific undercurrent which occasionally springs to the surface and becomes vociferous and sometimes violent. This anti-scientific attitude is very dangerous because it appeals to the emotional component of people and disregard rationality. The sole strategy to counteract it is to spread a scientific conscience by promoting a scientific and education culture, by placing science in the society. In order to do this we have to start with young pupils and students and Universities and research institutions must consider this an important part of their mission. The Workshop Science education and guidance in schools: the way forward is a clear demonstration that this has already begun.

Mario Enrico Pè

(Director of the Life Sciences Institute - Scuola Superiore Sant'Anna)



Good morning everyone,

It is my great pleasure and honour to warmly welcome all of you on behalf of the Dean of University of Florence, Prof. Alberto Tesi, to this conference organized by the CNR Institute of Biometeorology, together with the Sant'Anna School of Advanced Studies of Pisa and University of Florence, with the support of the Tuscany Region. This event, which in the next two days will see the participation of eminent Italian and foreign scholars, seems to be extraordinary for a number of reasons, which I can enunciate only partially since I do not want to take up time from the important lectures in agenda.

However, let me just spend few words in relation to ACARISS, the project which has given rise to the present reflection on the teaching and learning process of scientific disciplines and whose results will be presented today to both the national and international scientific community. Born from the collaboration among different institutions and financed by PAR-FAS, ACARISS is first and foremost an huge example of the synergy between research organizations and Universities which the University of Florence is focusing on. Indeed, in these difficult times, we are perfectly aware that this is the only way we can give our contribution to the development of the regional system of research and the process of transferring its knowledge to society.

As for the objectives of the research group and the main issue underlying both ACARISS and this event, I think it is not necessary to underline their central role at the international and national level. Suffice it to say that in Italy the alarming decline in young people's interest in scientific disciplines has been the rationale behind the Ministerial Project for scientific degrees (2,0151,999) and a subsequent Ministerial Plan (2,0202,003). In relation to the just-mentioned issue, it seems to me that both the research in question and the present conference provide us with significant new elements, whose scientific implications I am certainly not the right person to speak about. However, let me just identify what is maybe a new way to face the problem: I am referring to the capacity of combining the ultimate goal of increasing the appeal of degrees in scientific areas, with the commitment to instil a critical approach towards prejudices and stereotypes in young students (especially if women). Students orientation, which is not only an institutional, but also a civic and social duty for University, is indeed the area where both ACARISS and the present conference can contribute the most. Having said that, I would like to thank the the organizers of this event and wish you all a very productive conference.

L. Nozzoli

(Deputy Rector Academics and Student Services, University of Florence)



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ACARISS PROJECT: A TWO YEARS EXPERIENCE OF IBL METHOD FOR SCIENCE TEACHING IN SECONDARY SCHOOLS

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Abstract – Experimental activities are a powerful tool in science teaching and stimulate students learning and reasoning. In this paper we describe the framework of activities of the ACARISS (Increasing the knowledge on environment and pollution risks involving schools in experimental activities) project that adopted the IBSE (Inquiry Based Science Education) method. ACARISS started in May 2011 from the collaboration among three partners: Scuola Superiore Sant'Anna (Pisa), Institute of Biometeorology-CNR (Florence) and University of Florence. More than 30 secondary schools in Tuscany (Italy), distributed in several provinces engage the project activities. The main results have been a strong exchange of experiences between students, several practical guides for teachers reproducing numerous classroom scientific experiences; a website (www.acariss.it) acting as a coordination network, source of materials, blog and connection between schools.

Keywords: IBSE method, Research, Science education, School networking, 5E model.

Introduction

The Inquiry Based Science Education (IBSE) in Europe is a teaching approach which origins from the Inquiry Based Learning in United States. It is based on direct observation of phenomena, focusing on discussion and experimentation rather than on the mere transmission of theoretical information. Students are challenged with the object of the study, asking questions and formulating hypotheses, which are tested through experiments. This approach was promoted by the European Commission in the Rocard report (Rocard, 2007) as one of the methods to promote science education in school. Some examples are the CarboSchools+ Project (www.carboeurope.org) and the Inquire Project (www.inquirebotany.org/it/).

In Inquiry Based Learning, Bybee introduced the 5E Model (Bybee, 1997; Bybee *et al.*, 2006): it is composed by different phases, which guide the students during the discovering of science issues: Engage, Explore, Explain, Elaborate, and Evaluate.

- *Engagement:* the activity begins with the observation of a scientific problem, in which students are invited to reflect and ask questions, express their opinions and comments. This stage has the objective of attracting students' attention, stimulating curiosity,

encouraging the feeling of “wanting to know more.” It is the most important stage, because from this engagement derives the success of the whole learning process.

- *Exploration*: once focused on the object of investigation, students are directed towards the design of experiments that can provide answers to the addressed problems. Students identify the variables of the experiment and record, process and chart the obtained data.
- *Explanation*: in this step teachers provide the correct vocabulary, which allows students to explain results, introduce models, laws and theories and encourage independent research.
- *Elaboration*: students apply the new knowledge to other situations (transfer of learning) and new questions and hypotheses can be explored.
- *Evaluation*: as results, students produce a final product, which will be assessed either by teachers and researchers or by competing and exchanging with other students.

The ACARISS Project

Project objective

ACARISS project (Increasing the knowledge on environment and pollution risks involving schools in experimental activities) was born in 2011 from the synergy and collaboration among the three partners: Scuola Superiore Sant’Anna (Pisa), Institute of Biometeorology-CNR (Florence) and University of Florence. The project was aimed to make science learning more enjoyable and creating a link between schools and researchers. A group of University professors, researchers, PhD and technical staff worked in the project in collaboration with school teachers. The work included lessons for the students done by the ACARISS team members, training meetings for the school teachers and guided visits at the research Institutes and several questionnaires aimed at evaluating the project outcomes. The project products are several practical guides for teachers (didactic modules based on the 5E Model, aimed at reproducing numerous scientific experiences in classroom without the external experts); a dedicated website (www.acariss.it) acting as a coordination network, source of materials, blog and connection between schools.

Didactic modules

Twelve modules were developed by ACARISS team based on the 5E model (Figure 1): soil erosion, seeds germination, plants and environment, plants and salinity, eutrophication, robotics, meteorology, climatology, carbon cycle, phenology, weather sea, climate change and simulation models in biology. The modules were designed to include: *a*) instructions for teachers on how to introduce the scientific basis of the issue in the classroom; *b*) operating protocols for the description/implementation of experiments; *c*) tools and other materials such as photo tutorials and tables for data acquisition, useful in the experimental work. Educational modules were tested in the classroom and discussed with the teachers to be adapted to students’ age and to get improvements thanks to teachers experience. On the basis of the received feedback, modules were continuously modified and improved in order to make the teaching modules applicable to other school situations, independently from ACARISS project support.

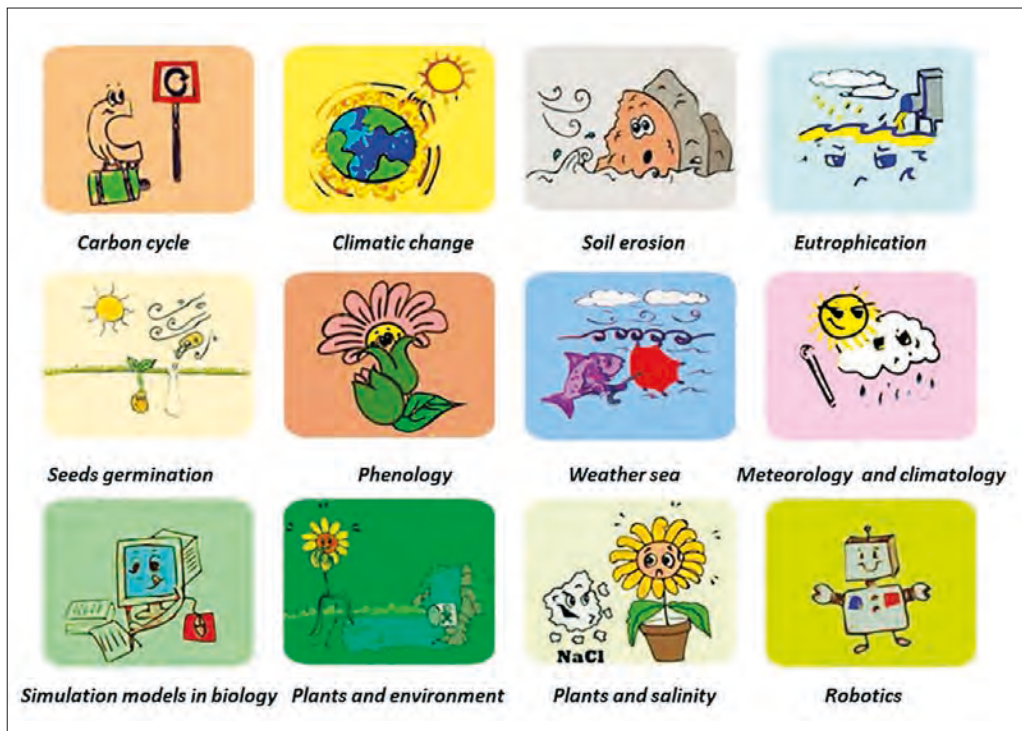


Figure 1. Icons of ACARISS modules as represented into web site (www.acariss.it).

Courses for teachers

Training seminars were organized to present modules and give indications for their use in the secondary school. The seminars were implemented following different levels of complexity, in order to provide the right teachers training to the different modules. Experimental activities, materials, methods, and guidelines for the quantitative and qualitative evaluation of the modules were presented and teachers discussed the modules directly with researchers.



Figure 2. Training course for teachers in the Sant'Anna Laboratories.

Moreover, ACARISS project contributed to the training of teachers and researchers, enhancing their communication skills in order to facilitate students learning based on IBSE. In particular, the basic principles of relational autonomy and empowerment education, during the teaching-learning process, were explained (Figure 2). Training covered the following contents: skills of active listening and response, possible answers, observation skills in listening as additional indicators of verification process, complexity in the comprehensive responses, insights on the various types of questions, reformulations of content and feeling. The aim is to facilitate student learning according to the “method of inquiry”, by an appropriate structure of the educational relationship, aimed at facilitating autonomy and self-efficacy in the processes of learning.

Psychological questionnaires

The objective was to evaluate project effectiveness using an experimental design with pre-, post-intervention and control groups. Specific questionnaires were constructed and used to assess: students’ attitudes towards science, the school and professional choices (choice of secondary school and of academic faculty). The questionnaires were submitted both to experimental group and to control group. The variables under study were detected at T1 (pre-intervention) and T2 (post-intervention) and data were processed in order to obtain the results of the intervention.

Research lessons in classroom

In order to introduce the module topic and to engage students, researchers gave some lessons in classroom. The Engagement phase was useful to feed students’ curiosity and researchers could answer directly to students’ questions and introduce the Exploration phase (Figure 3). Additional interactions with experts occurred through the project website.

Students experimentations

During Exploration phase, students carried on scientific experiments with different levels of complexity and on selected topics. Students (with teachers support) used material and human resources made available by the scientific partners of ACARISS and tried to



Figure 3. Researchers with students during the Engagement phase.



Figure 4. Student during the Exploration phase.

solve some scientific problems. Students acted as scientists, making hypothesis, testing and recording data and getting results from experiments (Figure 4).

Website

In order to reach and engage a large number of schools distributed in different geographical and socio-economic area of Tuscany region, it became necessary to support project dissemination, participation and community building between teachers and students of different schools.

The project website contains interactive sections customized for different stakeholders and allows to share materials and experiences in the training modules. For teachers, multimedia materials (examples of scientific experiments, slides, photography tutorials, etc.) were available as support during the experiments in classroom. For students, a Blog was developed in which they could write ideas, post photos and share materials with other students (Figure 5).



Figure 5. Acariss Website – www.acariss.it

The main function was to encourage involvement in training activities, increase the exchange of experiences, support the autonomy of participants in the activity, and finally incite to solving practical problems with a scientific approach.

Research products

School network

The ACARISS project created a network of more than 30 secondary schools in Tuscany (Italy) distributed in the provinces of Firenze, Livorno, Lucca, Pisa, Pistoia, Prato, Grosseto, Massa Carrara and Siena (Figure 6).

Final event

A competition between schools was launched to stimulate teachers and students to produce real results (design, plan and build a real scientific tool), after the implementation of a module in classroom. The competition was organized so that the different teams of students could work independently, supported and reviewed by intermediate validations of tutors (researchers). Each team, at the end of experimentation, submitted a final elaborate that could be a physical experiment, a photograph or a device representing the work done during the project. The best projects were selected and awarded by a jury of experts assessing the degree of complexity, innovation, originality and impact on the training of students (Figure 7).

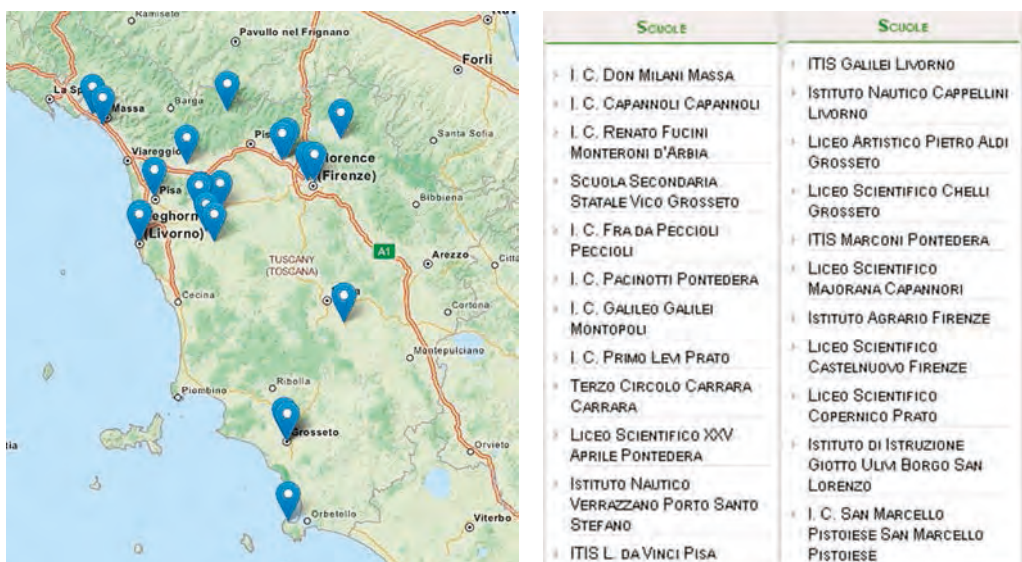


Figure 6. School network distribution.



Figure 7. Student showing their elaborates during ACARISS Workshop at Scuola Superiore Sant'Anna.

Conclusion

ACARISS was a successful project that promoted Science role and its positive perception in many secondary school students. Teachers involved in Science education have now available several didactic materials tested in classroom and improved with the contribute of other teachers. The website will continue to act as a coordination network, source of materials, blog and connection between schools.

Acknowledgement

We would like to thank all the teachers and students that participate the ACARISS project and the students' families for their support. This work was realized in the framework of the ACARISS project, funded by the Regione Toscana – PAR FAS 2007-2013, azione 1.1.a.3, Fondo per le Aree Sottoutilizzate, Delibera CIPE 166/2007.

References

- Rocard M., Csermely P., Jorde D., Lenzen D., Walberg-Henriksson H., Hemmo V. (2007). *A Renewed Pedagogy for the Future of Europe*. ISBN 978-92-79-05659-8.
- Bybee R.W. (1997). *Achieving scientific literacy: From purposes to practices*. Heinemann, Portsmouth, UK.
- Bybee R.W., Taylor J.A., Gardner A., Van Scotter P., Carlson Powell J., Westbrook A. & Landes N. (2006). *The BSCS 5E Instructional Model: Origins and Effectiveness*. BSCS Colorado Springs.

TEACHERS' EVALUATION OF THE 5E INSTRUCTIONAL MODEL IN ACARISS PROJECT

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Abstract – In secondary schools there is a progressive decline in motivation and interest in learning and attending science lessons. Teaching methodologies based only on frontal lessons are not effective anymore and the use of new tools and materials seems more and more attractive for the students. Nevertheless, an exacerbating home work is required from teachers which always need to searching for new inputs and new tools. A further issue is represented by the school curriculum which is more flexible only in lower grades of school. In this context, the team of Acariss project, has proposed the use of the 5E Instructional Model for teaching in science education, with special focus on current environmental issues. Eleven didactic modules were elaborated and piloted in the first year of the project. Then, the final agreed versions were spread in the second year of the project, during which teachers were asked to evaluate their own behavior during the five phases of the model, through a very short questionnaire. This took into consideration the indicators developed by Needham *et al.* (1994). The simple questionnaire allowed to get interesting results on what the teachers do and if they feel confident during the module application: teachers have the important role of facilitators in each phase. They introduce the phenomenon or environmental issue to be explained, they guide students into the discussion through questioning and causing doubts or disequilibrium among students. They do not teach but rather guide students in the exploration phase asking questions and posing doubts. Teachers help students to design, carry on the experiment and elaborating data to find conclusions. They also help students to clarify their findings and explanations, suggesting alternative methods of exploration and stimulating the extension of concepts through suggestions, providing resources, making further questions. Finally, since the students have to show their findings, teachers are fully involved showing examples and giving suggestions for the preparation of the final presentations. The 5E Instructional model was appreciated by the teachers especially for its effectiveness in students' understanding of the proposed environmental issue and in stimulating the students' interest and curiosity.

Keywords: Inquiry based learning, Instructional models, science education, secondary schools, teaching methodology

Introduction

Nowadays, teachers observe a progressive decline in interest and motivation of pupils in classroom. Therefore, it is recognised that teaching through frontal lessons does not work especially with young students, while the use of new tools and materials might be

more attractive. Nevertheless, the research of new methodologies and means of knowledge transfer might exacerbate the teacher's home work. A further difficulty is represented by the not flexible school curriculum especially in schools of higher grades, so that alternative methodologies are generally experimented in lower grades of secondary schools. In this context, typical of the Italian school system, Inquiry Based Learning (IBL) should be promoted for its effectiveness in increasing intellectual engagement and fostering deep understanding through the application of the scientific method. Nevertheless, in recent years this methodology is going toward a wider use even far from the United States of America where it origins. This approach is ideal for dealing with scientific topics. In fact, respect to the past, more and more resources have been created and are available for carrying out hands-on activities and experiments in classroom.

The key of IBL is the central role of the student in the learning process: the comprehension of concepts is based on questions and practical experiences. The essential characteristics for inquiry are: engagement of students by scientifically oriented questions; giving priority to evidence in order to develop and evaluate explanations; formulation of explanations from evidence; evaluation of explanation; communication and justification of proposed explanation.

In about 40 Tuscan schools, the team of ACARISS project (Increasing the knowledge on environmental issues and pollution risks involving school with experimental activities) used the 5E Instructional Model (Bybee *et al.*, 2006) to develop didactic modules on environmental issues. The approach was first used in the States in the early 1970s, then several models have been described in literature (Barman, 1989; Ramsey, 1993; Osborne and Wittrock, 1983). The 5E Instructional Model was adopted since considered feasible and adaptable for the Italian context. It discerns the learning process of a didactic module in five phases or steps with specific purposes. In table 1, the five phases of the 5E Instructional Model are summarized.

The teachers behavior in 5E Instructional Model was assessed through a simple

Table 1. Summary of the 5E Instructional Model by the Biological Science Curriculum Studies (Bybee *et al.*, 2006).

PHASE	SUMMARY
Engagement	"The teacher [...] accesses the learners' prior knowledge and helps them become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. [...]"
Exploration	"Exploration experiences provide students with a common base of activities within which current concepts (i.e., misconceptions), processes, and skills are identified and conceptual change is facilitated. Learners may complete lab activities that help them use prior knowledge to generate new ideas, explore questions and possibilities, and design and conduct a preliminary investigation".
Explanation	"The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviors. [...]"
Elaboration	"Teachers challenge and extend students' conceptual understanding and skills. Through new experiences, the students develop deeper and broader understanding, more information, and adequate skills. Students apply their understanding of the concept by conducting additional activities".
Evaluation	"The evaluation phase encourages students to assess their understanding and abilities and provides opportunities for teachers to evaluate student progress toward achieving the educational objectives".

questionnaire which took into consideration the indicators proposed by Needham *et al.* (1994) for a four step learning cycle model (Bentley *et al.*, 2000).

Methodology

The questionnaire included one question on the teacher's autonomy to run the didactic module including the autonomy to get tools or instruments, information sources and to conduct the activities in classroom.

Teachers behaviour was assessed on the base of indicators suggested by Needham *et al.* (1994) for the four step learning cycle model (Bentley *et al.*, 2000). This model consists of the first four phases of the 5E Model. The indicators used in this project are showed in table 2.

Then, teachers were invited to score their level of agreement on those indicators (1=not at all agree, 2=a little agree, 3=rather agree, 4=agree, 5=totally agree).

Table 2. Indicators used to evaluate the teacher's behaviour in each phase of the 5E Model. Eventually, the questionnaire assessed the effectiveness of the module to acquire new knowledge and rise curiosity and interest in students.

PHASE	THE TEACHER
Engage	Poses problems
	Asks questions
	Reveals discrepancies
	Causes disequilibrium or doubt
	Assess prior knowledge
Explore	Makes surveys
	Asks questions
	Reveals discrepancies
	Causes disequilibrium or doubt
	Assess prior knowledge
Explain	Provides feedback
	Asks questions, poses new problems and issues
	Proposes alternative methods to explain the issue
	Offers alternative explanations
	Enhances or clarifies explanations
Elaborate	Evaluates students explanations
	Provides feedback
	Asks questions
	Offers information sources
	Makes suggestions
Evaluate	Evaluates students
	Provides examples
	Organizes the work
	Provides sources of information
	Makes suggestions
Evaluate	Assesses students' work
	Assesses students' skills and attitudes

Results and discussion

25 teachers were involved in the second year of project implementation and 17 of them participated to this evaluation survey, filling one form per classroom involved into the project. Therefore, 26 filled questionnaires were finally obtained, one per implementation. The evaluation concerned 9 modules on carbon cycle; 7 modules on robotics; 6 modules on meteorology; 3 modules on salinity and plants; 1 on water eutrophication.

First of all, we present the results concerning the autonomy in carrying on the module in the classroom (table 3).

Teachers were autonomous in setting up the activities of Engagement (Mean: 3.5; Min: 2; Max: 4), facing just a few problems (Mean: 2.2; Min: 1; Max: 4). In this phase, materials and activities were suggested by the modules, therefore they were also autonomous in leading the activity (Mean: 3.5; Min: 2; Max: 4).

In the Exploration phase teachers faced problems a little more than previously (Mean: 2.7; Min: 1; Max: 4) but they were rather autonomous in finding materials (Mean: 3.0; Min: 2; Max: 4), sources of information (Mean: 3.3; Min: 2; Max: 4) and leading the activity (Mean: 3.4; Min: 2; Max: 4).

In the Explanation phase teachers agreed about the difficulties met (Mean: 3.0; Min: 2; Max: 4). Nevertheless, they were rather autonomous in finding materials (Mean: 3.3; Min: 2; Max: 4) and sources of information (Mean: 3.3; Min: 2; Max: 4) but also in leading the activity in classroom (Mean: 3.4; Min: 2; Max: 4).

Elaboration phase was not very difficult (Mean: 2.8; Min: 1; Max: 3) for teachers and they could find materials (Mean: 3.2; Min: 1; Max: 4) but also sources of information (Mean: 3.3; Min: 2; Max: 4) rather autonomously.

In Figure 1 average scores for teacher's behavior actions concern the five phases.

During the Engagement phase, most teachers introduced an environmental issue (Mean: 4.3; Min: 2; Max: 5) to the students and made questions (Mean: 4.1; Min: 2; Max: 5) in order to initiate the debate and the exploration activity. They did not reveal discrepancies (Mean: 2.4; Min: 1; Max: 5) among students opinions but they were rather agree in causing disequilibrium or doubts (Mean: 3.1; Min: 1; Max: 5). Moreover, teachers assess the students' prior knowledge (Mean: 3.4; Min: 1; Max: 5).

In the Exploration phase pupils carry on experiments, hands-on activities etc. Teachers use to make questions (Mean: 4.2; Min: 3; Max: 5) to the students or cause doubts (Mean: 3.1; Min: 1; Max: 5). They neither reveal discrepancies (Mean: 2.8; Min: 1; Max: 5) among students opinions, therefore, they do not use to make opinion surveys in the class

Table 3. Teachers difficulties and autonomy in carrying on the first phases of 5E Instructional Model.

	Teacher faces problems and difficulties in setting up the activities	Teacher is autonomous for finding materials	Teacher is autonomous in finding sources of information	Teacher is autonomous in leading the activity
Engage	2.2	3.0		3.5
Explore	2.7	3.0	3.3	3.4
Explain	3.0	3.3	3.3	3.4
Elaborate	2.8	3.2	3.3	3.3

1= not at all agree; 2= a little agree; 3= rather agree; 4= totally agree

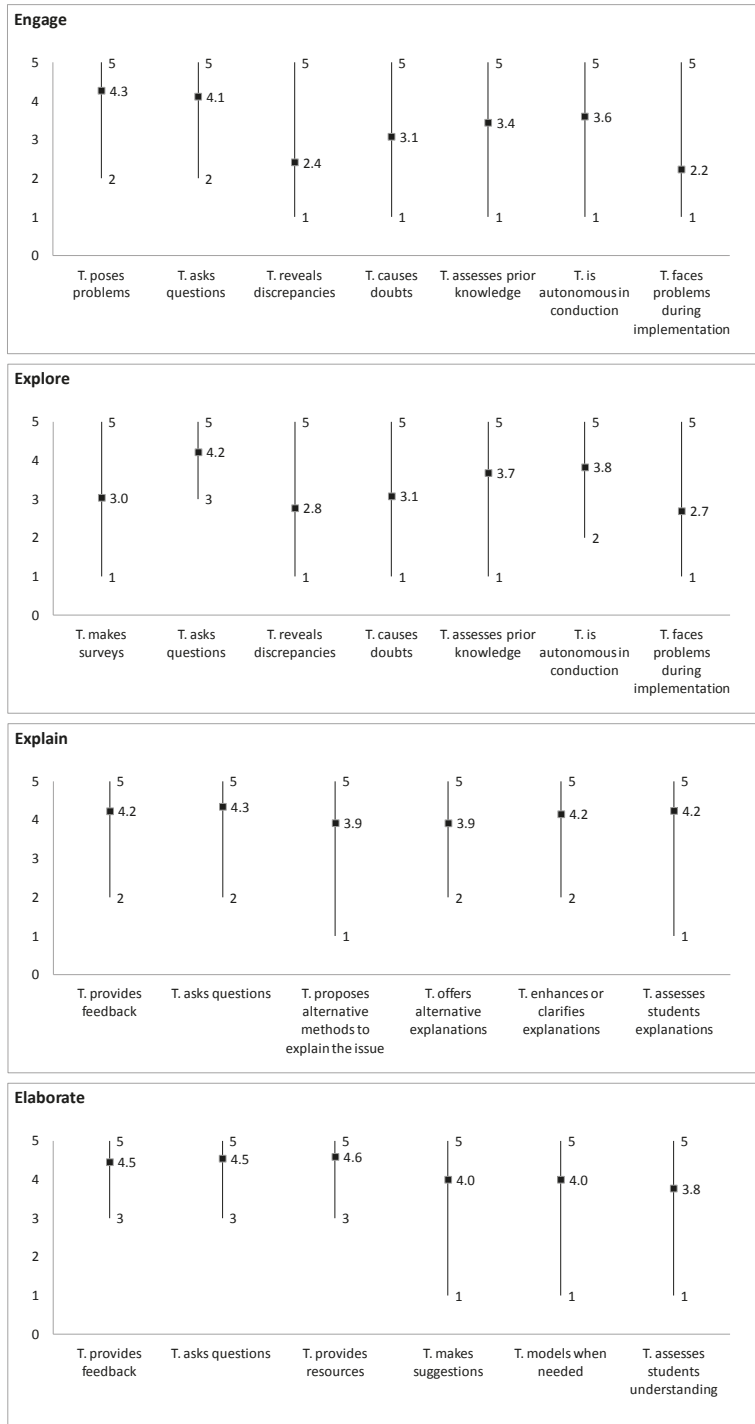


Figure 1. Minimum, average and maximum scores for the teachers behaviour in four phases of the 5E Instructional Model.

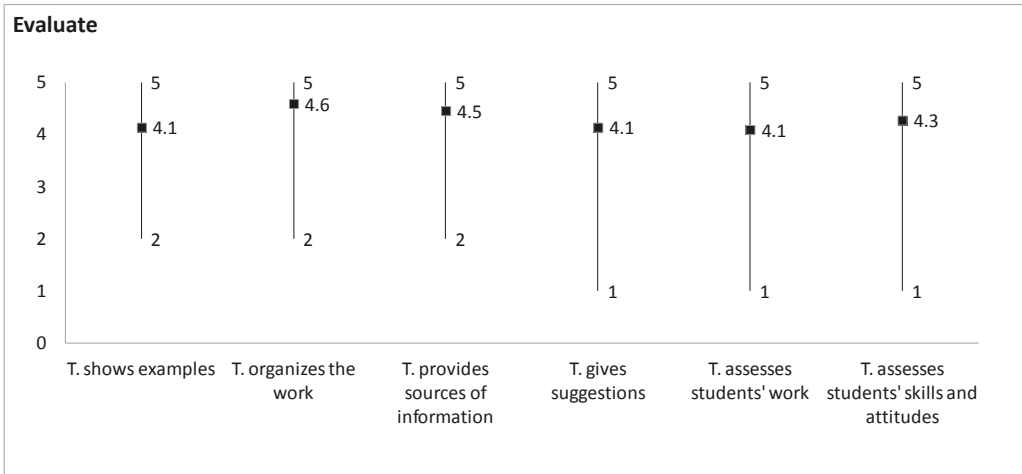


Figure 2. Average scores for the teachers behaviour in Evaluate phase of the 5E Instructional Model.

(Mean: 3; Min: 1; Max: 5). Moreover, even in this phase, teachers assess the students' prior knowledge (Mean: 3.7; Min: 1; Max: 5).

In the Explanation phase pupils have to explain and discuss their data or experiment observations. They might find explanations to phenomena. Teachers usually provide feedback on the activities carried out during the previous phase (Mean: 4.2; Min: 2; Max: 5) and make questions (Mean: 4.3; Min: 2; Max: 5) to pupils. Although this, they also propose alternative methodologies and experiments to find explanations (Mean: 3.9; Min: 1; Max: 5) and offer explanations alternative to the students' ones (Mean: 3.9; Min: 2; Max: 5). Moreover, teachers enhance or clarify students' explanations (Mean: 4.2; Min: 2; Max: 5) which are also evaluated (Mean: 4.2; Min: 1; Max: 5).

In the Elaboration phase pupils have to extend their acquired knowledge to further contexts. Teachers provide feedback (Mean: 4.5; Min: 3; Max: 5) on the activities carried out and obtained results. They usually make questions (Mean: 4.5; Min: 3; Max: 5) and provide further resources (Mean: 4.6; Min: 3; Max: 5). Moreover, they use to give suggestions (Mean: 4.0; Min: 1; Max: 5) and model findings when needed (Mean: 4.0; Min: 1; Max: 5). Eventually, they are agree to assess student understanding (Mean: 3.8; Min: 1; Max: 5).

In figure 2, the average scores for actions relative to teacher's behavior in the Evaluation phase are given. In this phase pupils have to summarize their findings and produce reports or posters to present in classroom or in events. Teachers show examples (Mean: 4.1; Min: 2; Max: 5) of the work to do and mostly they organize the work (Mean: 4.6; Min: 2; Max: 5). They usually provide sources of information (Mean: 4.5; Min: 2; Max: 5) and use to give suggestions (Mean: 4.1; Min: 1; Max: 5). Eventually, the students' work is assessed (Mean: 4.1; Min: 1; Max: 5).

Mean scores for explanation and elaboration were slightly high. This suggests that teachers had the capacity to guide the students and suggest alternative ways to explore and explain the results, even though sometimes teachers needed to be assisted and supported by the scientists in this experimental phase.

Table 4. Final evaluation of the module effectiveness. The modules were built according the 5E Instructional Model

EFFECTIVENESS OF THE MODULES	MEAN	MIN	MAX
Students' understanding of the proposed environmental issue	4.3	3	5
Students' stimulation of interest and curiosity	4.5	3	5

1=not at all agree, 2=a little agree, 3=agree, 4=totally agree

Finally, the effectiveness of the module was evaluated by teachers. The application of inquiry based learning imply that students apply different abilities or skills. Teachers assessed students' knowledge in every phase of the learning model, and finally even their skills and attitudes (Mean: 4.3; Min: 1; Max: 5) were assessed. The learning 5E model was generally effective for students' understanding of the environmental issue and it was also very effective in stimulating the pupils' interest and curiosity toward scientific issues. The scores were good with positive minimum values (table 4).

Conclusions

The simple questionnaire allowed to get interesting results on what teachers do during the module application. From this analysis, we have obtained that teachers act as facilitators in each phase of the learning process. Teachers introduce the environmental issue or phenomena to be explained; they guide the engagement of students through questions and causing doubts or disequilibrium among them during the discussion. There is not direct teaching in the exploration phase, rather a guidance through questions and sometime creating doubts. Teachers help students to design, carry on the experiments, elaborate data to find conclusions, but they also help students to clarify their findings and explanations, suggesting alternative methods of exploration and stimulating the extension of concepts through suggestions, further resources and questioning. Finally, since the students need examples and suggestions for the preparation of the final presentations, teachers are fully involved in the last phase of the model.

To conclude, the 5E Instructional model was appreciated by the teachers especially for its effectiveness in students' understanding of the proposed environmental issue and in stimulating the students' interest and curiosity. We got also several positive comments and some critical observation which basically concerned the more time needed to apply the learning model and the big challenge to organise all planned activities in crowded classes.

Acknowledgements

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References

- Barman C. (1989). Making it work. *Science Scope*, 12 (5), 28-31.
- Bybee R.W., Taylor J.A., Gardner A., Van Scotter P., Carlson Powell J., Westbrook A. & Landes N. (2006). *The BSCS 5E Instructional Model: Origins and Effectiveness*. BSCS Colorado Springs
- Needham R.A., Powell D. & Bentley M.L. (1994). *Using big books in science and social studies*. Paper presented at the Annual Meeting of the International Reading Association, Toronto, Canada.
- Ramsey J. (1993). Developing conceptual storylines with the learning cycle. *Journal of Elementary Science Education*, 5 (2), 1-20.
- Osborne R. & Wittrock, M. (1983). Learning science: A generative process. *Science Education*, 67 (4), 489-508.

Web references

<http://faculty.mwsu.edu/west/maryann.coe/coe/inquire/inquiry.htm>, visited on July 15th, 2013.

EVALUATION OF EFFECTIVENESS OF ACARISS PROJECT: NEW PERSPECTIVE FOR DEVELOPING TALENTS IN THE FIELD OF SCIENCE

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Abstract – This study is part of the ACARISS Project promoted in Italy by the Region of Tuscany with the aim of developing innovative approaches for improving learning of the scientific disciplines and enhancing talents of students. The objective of the present study is to evaluate the effectiveness of the intervention for promoting career choice in the scientific field. The present work evaluated the effectiveness of the intervention using a pre and post-experimental design with a control group. Attitudes towards science, career decision-making difficulties, career decision-making self-efficacy were investigated. The results showed the effectiveness of the intervention highlighting an increase of positive attitudes towards science, of career decision-making self-efficacy and a reduction of career decision-making difficulties.

Keywords: attitudes towards science, career choice, career decision-making self-efficacy, career decision-making difficulties

Introduction

ACARISS (Increasing knowledge on Environment and on Risks associated with Pollution Involving Schools through Experimentation) project is promoted in Italy by the Tuscany Region. It aims at connecting schools to research laboratories, developing innovative approaches to improve learning of scientific disciplines.

In recent years it has been shown a declining interest of young people in science and mathematics (Brandi, Cerbara, Misiti, & Valente, 2005) and has emerged an increasingly attention to the problem of decreased interest of the younger generation for scientific faculties (Ministry of Education Research – Bureau of Statistics, 2008), including gender differences, with males more interested in science than females (Gouthier, Manzolis, & Ramani, 2008; Stake & Nickens, 2005; Stevens, Wang, Olivarez, & Hamman, 2007).

ACARISS project therefore aims to provide a significant contribution regarding this complexity. It is essential to emphasize the importance of direct and regular contacts between young people and the scientific community in order to promote the progress of science. The principal aim of ACARISS project consists of connecting the world of education (secondary school teachers in middle and high school) with that of research (researchers

at the University and CNR), developing innovative approaches to facilitate and make more pleasant learning scientific disciplines. The broader aim is to foster the growth of the research system in Tuscany, promoting and transferring the results of research and new technologies in schools, and consequently in the local community.

Another important aim of ACARISS project consists of stimulating the use of the experimental method in the teaching of science to promote the active participation of the student in learning of scientific disciplines and in particular phenomena related to the environment. The method proposed in ACARISS project is based on the direct observation of phenomena, focusing on the discussion and experimentation in the classroom, as an essential complement for the transmission of theoretical knowledge (Bybee *et al.*, 2006; Huber & Moore, 2001; Rocard Report, 2007). This approach is beginning to spread and is increasingly demanded by the European Community programs on science dissemination (Rocard Report, 2007). The researchers of CNR-IBIMET and the Scuola Superiore Sant'Anna cooperated with teachers in a constructive way for the production of training modules applicable in class and based on the method of inquiry (Inquiry Based Learning). This method of teaching is aimed at stimulating the students to formulate questions and investigative actions to solve problems and understand phenomena (Bybee *et al.*, 2006; Huber & Moore, 2001; Rocard Report, 2007) actively participating in the learning process.

The Research and Intervention Laboratory of Psychology for Vocational Guidance and Career Counseling of the Department of Education and Psychology at the University of Florence, relying on its specific expertise provided its contribution to the construction of such modules in accordance with the basic principles of a learning facilitation autonomy of the student. The Department of Education and Psychology has also promoted the enhancement of soft skills of trainers (teachers and researchers) so that they can practically and effectively facilitate the students' learning based on the Inquiry Based Learning. These measures have allowed the enhancement of trainers' relational skills (teachers and researchers) for innovative, participatory, self-monitoring and empowering didactics to enhance process of autonomy, self-efficacy and students' agency in the learning process.

The Research and Intervention Laboratory of Psychology for Vocational Guidance and Career Counseling of the Department of Education and Psychology at the University of Florence also evaluated the effectiveness of the intervention using a pre and post-experimental design with a control group. So the aim of the present study was to verify the effectiveness of the intervention using a pre and post-experimental design with a control group to promote career choice in the scientific field.

Specifically the hypotheses are the following:

- H1: in the experimental group the intervention will increase students' positive attitudes towards science (Kind, Jones, & Barmby, 2007)
- H2 : in the experimental group the intervention will decrease career decision-making difficulties (Gati, Krausz, & Osipow, 1996; Whiston, 2008)
- H3: in the experimental group the intervention will increase career decision-making self-efficacy (Gati *et al.*, 1996; Whiston, 2008)

Methodology

Participants

Regarding the first year of ACARISS project, the experimental group consists of 446 middle and high schools students between 10 and 20 years of age ($M = 13.97$, $SD = 2.32$) coming from different provinces of the Tuscany Region. Each participant filled instruments at T1 before the intervention and at T2 after the intervention. This experimental group was compared to a control group who consists of 474 middle and high schools students between 11 and 19 years of age ($M = 14.68$, $SD = 1.97$) coming from different provinces of the Tuscany Region. This control group didn't receive any intervention between the first administration (T1) and the second administration (T2) of the instruments and they filled the questionnaires in voluntary manner.

Regarding the second year of ACARISS project, The experimental group consists of 563 middle and high schools students between 11 and 18 years of age ($M = 13.20$, $SD = 1.81$) coming from different provinces of the Tuscany Region.

Each participant filled instruments at T1 before the intervention and at T2 after the intervention. This experimental group was compared to a control group who consists of 365 middle and high schools students between 11 and 19 years of age ($M = 13.52$, $SD = 1.79$) coming from different provinces of the Tuscany Region. This control group didn't receive any intervention between the first administration (T1) and the second administration (T2) of the instruments and they filled the questionnaires in voluntary manner.

Measures

Questionnaire for detecting students' attitudes towards science (Kind *et al.*, 2007) in the Italian version by Di Fabio and Palazzeschi (in press). It consists of 46 item and it has response options in a 5-point Likert scale (ranging from 1 = *Strongly disagree* to 5 = *Strongly agree*). The tool allows to detect seven factors: Learning science in school, Self-concept in science, Practical work in science, Science outside of school, Future participation in science, Importance of science, General attitudes towards school.

Career Decision-Making Difficulties Questionnaire (Gati *et al.*, 1996), short version (34 items), in the Italian version by Di Fabio and Palazzeschi (2010, 2013) was used. This tool has response options in a 9-point Likert scale format (ranging from 1 = *Does not describe me* a 9 = *Describes me well*). This questionnaire distinguishes 3 scales and 10 subscales: Lack of Readiness (Lack of Motivation; Indecisiveness; Dysfunctional Beliefs); Lack of Information (Lack of information about the decision making process; Lack of Information about the Self; Lack of Information about occupations; Lack of information about ways of obtaining information); Inconsistent Information (Unreliable Information; Internal Conflicts; External Conflicts).

Career Decision Self-Efficacy Scale - Short Form (Betz, & Taylor, 2000) in the Italian version by Nota, Pace and Ferrari (2008). The Italian version comprises 20 items, with a 5-point Likert scale (1 = *I have no confidence* to 5 = *I have complete confidence*). The scale consists of four factors: Efficacy beliefs in one's own abilities to pursue one's own educational and vocational goals, Efficacy beliefs in one's own abilities of problem solving, Efficacy beliefs in one's own abilities to identify educational and vocational objectives, and Efficacy beliefs in one's own abilities to support one's own work placement).

Procedure

The present work evaluated the effectiveness of the intervention using a pre- and post-experimental design with a control group. The experimental group filled instruments before (T1) and after (T2) the intervention. This kind of intervention aimed to enhance the awareness of their educational-vocational choice in order to promote talents in scientific discipline. This experimental group was compared to a control group who didn't receive any intervention between the first administration (T1) and the second administration (T2) of the instruments. The students of the control group have done the usual educational activities between T1 and T2. In Figure 1 the procedure followed in this study is showed.

Data analysis

One-way Analysis of Variance (ANOVA) were carried out to see if there were no statistically significant differences between the mean scores on the measures between the experimental group and the control group during pre-testing.

A repeated measures analysis with one between-subjects independent variable (experimental group/control group) and one within-subjects variable (time: T1/T2) were carried out to assess group changes over time, so to assess the effect of intervention.

Results and discussion

Regarding the data collected during the first year of ACARISS project, the results of ANOVA at pre-test showed no statistically significant differences between the experimental group and the control group in relation to the examined variables.

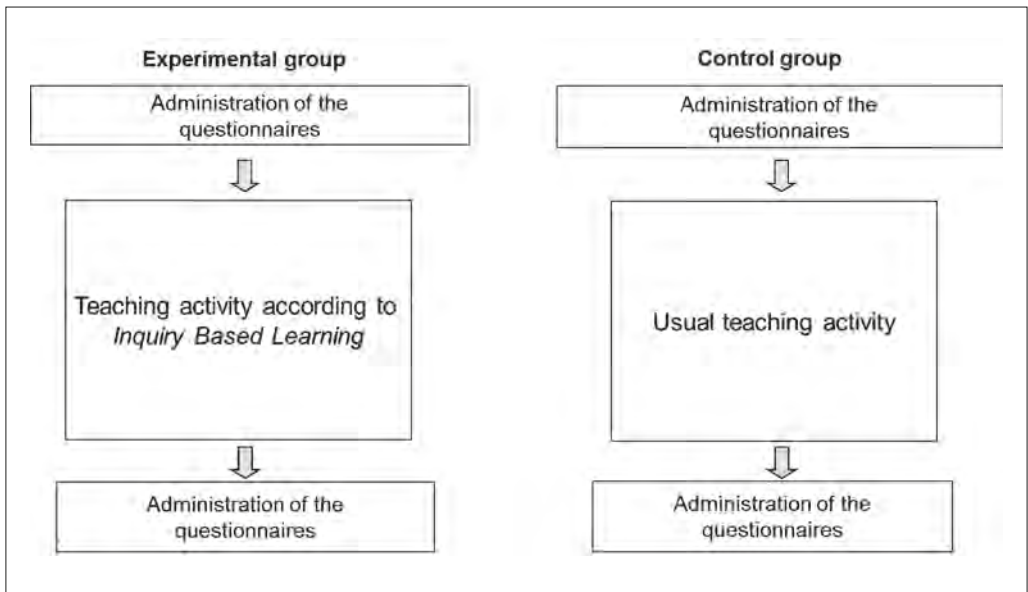


Figure 1. Procedure of the study

From the repeated measures analysis with one between-subjects independent variable (experimental group/control group) and one within-subjects variable (time: T1/T2) statistically significant differences emerged between pre-test and post-test in the experimental group.

In particular regarding the students' attitudes towards science, an increase emerged for: Learning science in school ($F(3,916) = 5.03, p < .05, \eta^2 = .05$); Self-concept in science ($F(3,916) = 5.37, p < .05, \eta^2 = .06$); Practical work in science ($F(3,916) = 7.47, p < .01, \eta^2 = .08$); Future participation in science ($F(3,916) = .28, p < .05, \eta^2 = .06$); Importance of science ($F(3,916) = .87, p < .05, \eta^2 = .05$). Regarding career decision-making difficulties a decrease emerged for Inconsistent information ($F(3,916) = 3.46, p < .05, \eta^2 = .04$). Regarding *career decision-making self-efficacy* an increase emerged: ($F(3,916) = 5.19, p < .05, \eta^2 = .05$).

Regarding the data collected during the second year of ACARISS project, the results of ANOVA at pre-test showed no statistically significant differences between the experimental group and the control group in relation to the examined variables.

From the repeated measures analysis with one between-subjects independent variable (experimental group/control group) and one within-subjects variable (time: T1/T2) statistically significant differences emerged between pre-test and post-test in the experimental group, confirming the results obtaining during the first year of ACARISS project.

In particular regarding the students' attitudes towards science, an increase emerged for: Learning science in school ($F(3,924) = 4.12, p < .05, \eta^2 = .06$); Self-concept in science ($F(3,924) = 4.26, p < .05, \eta^2 = .07$); Practical work in science ($F(3,924) = 6.34, p < .01, \eta^2 = .09$); Future participation in science ($F(3,924) = 1.35, p < .05, \eta^2 = .04$); Importance of science ($F(3,924) = 1.46, p < .05, \eta^2 = .06$). Regarding career decision-making difficulties a decrease emerged for Inconsistent information ($F(3,924) = 4.34, p < .05, \eta^2 = .06$). Regarding *career decision-making self-efficacy* an increase emerged: ($F(3,924) = 6.43, p < .05, \eta^2 = .07$).

The present study with control group allows to show the effectiveness of the intervention highlighting an increase of positive attitudes towards science and an increase of career decision-making self-efficacy and a reduction of career decision-making difficulties in particular inconsistent information.

The first hypothesis was confirmed: the intervention increased students' positive attitudes towards science (Kind *et al.*, 2007). In particular: Learning science in school; Self-concept in science; Practical work in science; Future participation in science; Importance of science. These results are particularly significant because positive attitudes towards science are related to more persistent science interest and involvement of students (Kind *et al.*, 2007; Krappa & Prenzel, 2011). Students with more positive attitudes towards science could be more able to recognize their interest in science favoring a more congruent career choice.

Even the second hypothesis was confirmed: the intervention reduced career decision-making difficulties (Gati *et al.*, 1996). In particular Inconsistent information was reduced, underlining as the intervention reduced the perception of having unreliable information and internal and external conflicts. After the intervention students seem to perceive more reliable information relative to possible career paths and seems to perceive a lower conflicts regarding what they want and what others want for them in relation to the development of their scholastic and career path (Gati *et al.*, 1996).

Finally the third hypothesis was confirmed: the intervention increased career decision-making self-efficacy (Gati *et al.*, 1996; Whiston, 2008), the perception of students to be more able in decision-making process facilitating students in developing a scholastic or

professional path. Consistent with the literature (Gati *et al.*, 1996; Whiston, 2008), career decision-making difficulties and career decision-making self-efficacy are considered as indexes of effectiveness of guidance intervention.

On the basis of all these results the intervention in ACARISS project emerged as effective in promoting career choice in scientific field.

Conclusions

The results of the present study underlined the effectiveness of the intervention highlighting an increase of positive attitudes towards science and an increase of career decision-making self-efficacy and a reduction of career decision-making difficulties, although it is necessary to point out some limitations of this research. It is important to highlight the impossibility of generalizing the results of the present work, obtained in a specific sample of Italian students. In future research it would be desirable to involve participants more representative of the Italian context, taking into consideration students from other Italian regions. It is important also to replicate the study in other international contexts.

Notwithstanding the above-mentioned limitations, if the results of the present study will be confirmed in future research the intervention on the experimental group could help to increase students' awareness of their educational-vocational choice for the construction of a congruent professional path, encouraging the promotion of talents in scientific disciplines.

References

- Betz N.E. & Taylor K.M. (2000). *Manual for the Career Decision Making Self-Efficacy Scale (CDMSES) and CDMSES – Short Form*. Unpublished Manuscript, Ohio State University, Columbus, OH.
- Brandi M.C., Cerbara L., Misiti M. & Valente A. (2005). *Giovani e scienza in Italia tra attrazione e distacco*. *Journal of Science Communication*, 4 (2), 1-15.
- Bybee R.W., Taylor J.A., Gardner A., Van Scotter P., Powell J.C., Westbrook A. & Landes N. (2006). *The BSCS 5E instructional model: Origins and effectiveness*. Colorado Springs, CO: BSCS.
- Di Fabio A. & Palazzeschi L. (2010). Career Decision-Making Difficulties Questionnaire: Proprietà psicometriche nel contesto italiano. *Counseling. Giornale Italiano di Ricerca e Applicazioni*, 3, 351-364.
- Di Fabio A. & Palazzeschi L. (Eds) (2013). *Adattamento italiano del CDDQ – Career Decision-making Difficulties Questionnaire*. Firenze: Giunti O.S.
- Di Fabio A. & Palazzeschi L. (in press). Questionnaire for detecting students' attitudes towards science: Psychometric properties in the Italian context.. *Counseling. Giornale Italiano di Ricerca e Applicazioni*.
- Gati I., Krausz M. & Osipow S.H. (1996). A taxonomy of difficulties in career decision-making. *Journal of Counseling Psychology*, 43 (4), 510-526.
- Gouthier D., Manzoli F. & Ramani D. (2008). Scientific career and gender differences. A qualitative study. *Journal of Science Communication*, 7 (1), 1-3.
- Huber R.A. & Moore C.J. (2001). A model for extending hands-on science to be inquiry based. *School Science and Mathematics*, 101 (1), 32-42.

- Kind P.M., Jones K., Barmby P. (2007). Developing attitudes towards science measures. *International Journal of Science Education*, 29 (7), 871-893.
- Krappa A. & Prenzel M. (2011). Research on Interest in Science: Theories, methods, and findings. *International Journal of Science Education*, 33 (1), 27-50.
- Ministry of Education Research – Bureau of Statistics (2008). *Monitoraggio degli immatricolati al sistema Universitario [Monitoring enrolled in the university system]*. Retrieved from <http://statistica.miur.it/ustat/Statistiche/Immatricolati.asp>.
- Rapporto Rocard (2007). *Science education now: A renewed pedagogy for the future of Europe*. European Commission. Retrieved from http://ec.europa.eu/research/science_society/document_library/pdf_06/report-rocard-on-science-education_en.pdf
- Stake J.E. & Nickens S.D. (2005). Adolescent girls' and boys' science peer relationships and perceptions of the possible self as scientist. *Sex Roles*, 52, 1-11.
- Stevens T., Wang K., Olivárez A. Jr. & Hamman D. (2007). Using self-perspectives and their sources to predict the mathematics enrolment intentions of girls and boys. *Sex Roles*, 56, 351-363.
- Whiston S.C. (2008). *Principles and applications of assessment in counseling* (3rd ed.). Belmont, CA: Brooks/Cole.

THE USE OF WEB TECHNOLOGY IN SCIENCE EDUCATION: THE CASE STUDY OF ACARISS PROJECT

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Abstract – This paper describes the case study of ACARISS project, as an example of collaboration between schools and universities. In particular, the project aims to combine the competences of teachers and researchers in order to facilitate the learning of science and technology in secondary schools. In this contest, a specific website was developed to help researchers, teachers and students sharing materials, describing the progress of class activities and exchanging experiences between schools.

Keywords: IBSE model, Research on Education, Science Education, Website and Blog

Introduction

This work presents the case study of ACARISS (*Accrescere le Conoscenze sull'Ambiente e i Rischi connessi all'Inquinamento coinvolgendo le Scuole con la Sperimentazione*) project. The ACARISS main objective is to promote the collaboration between Schools and Universities and to combine the competences of teachers and researchers in order to facilitate the learning of science and technology in secondary schools.

The project adopted the IBSE (Inquiry Based Science Education) approach, an educational method promoted by European Commission (Rocard *et al.*, 2007). Specifically, the 5E model was used, which is composed by five steps (Bybee *et al.*, 2006). Engage: the activity starts by observing and discussing a scientific problem, this stage has the scope of stimulate curiosity. Explore: students carry on experiments and record data. Explain: teachers introduce models, laws and theories. Elaborate: transfer of learning to other situations and problems. Evaluate: the final products are evaluated either by teachers and researchers. European Community is encouraging the collaboration between school and research through the Inquiry approach. Some examples of are the CarboSchools+ Project (www.carboeurope.org) and the Inquire Project (www.inquirebotany.org/it/), both applied in Italian schools.

Table 1. Schools involved in ACARISS community

SCHOOL YEAR	LOWER SECONDARY SCHOOLS	SECONDARY SCHOOLS
2011/2012	17 classrooms of 5 schools	20 classrooms of 9 schools
2012/2013	32 classrooms of 8 schools	15 classrooms of 11 schools

Methodology

The ACARISS project created an online community of more than 30 secondary schools in Tuscany, distributed in the provinces of Firenze, Livorno, Lucca, Pisa, Pistoia, Prato, Grosseto, Massa Carrara and Siena (Figure 1).

A dedicated website was developed in order to support and engage a large number of schools distributed in different geographical areas. The website (www.acariss.it) promotes participation and builds a community among students, teachers and scientists. It supports and extends educational activities by providing access to information, data and tools for scientific explorations. In the framework of ACARISS, different didactic modules based on the IBSE 5E Model were developed by a team of scientists: seeds germination, plants and environment, plants and salinity, eutrophication, robotics, meteorology and climatology, carbon cycle, climatic change, simulation models in biology. Each module includes a brief scientific introduction, a description of activities, materials and methods for experiments, photo tutorials and tables for data acquisition to guide students during the school activity. The interactive multimedia elements were tested for prompt accessibility by devices in schools, such as the interactive whiteboard (LIM). A dedicated space was also created to show meteorological data acquired by different weather station distributed in different institutes, which can be used during the laboratory on meteorology.

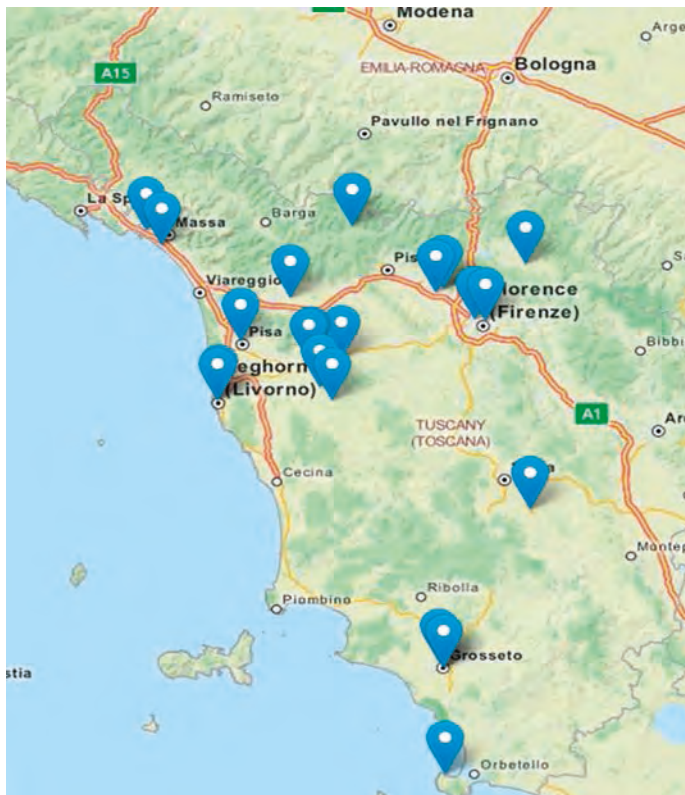


Figure 1. Maps of the ACARISS project schools community.

Moreover, the ACARISS website contains a section dedicated to the blog (Figure 2), where students, teachers and researchers can publish posts. The blog represents a multidimensional space, being at the same time a place of interaction, an environment for cooperative learning and an historical database of the activities. Students are encouraged to share their works, providing scenarios for future ideas and projects. Again, it is also useful to solve problems related to the experimental procedure, like in a peer-cooperation between students. Teachers have access to additional resources and, moreover, they can manage and correct posts and photos of their students in order to control the contents before the on-line publication.

Home | Accessibilità | Mappa del Sito

userID

ACARISS

Accrescere le Conoscenze sull'Ambiente e i Rischi connessi all'Inquinamento Coinvolgendo le Scuole con la Sperimentazione

02-12-2013

REGIONE TOSCANA
F38
Fondo Azioni
Domestico
02/12/2013

Home | Eventi | Attività Didattiche | Scuole | TOSCO2net | Blog

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BLOG

INTERNATIONAL WORKSHOP

Scritto da Francesca Ugolini - IBIMET il 31-10-13 10 07

Nelle giornate del 21-22 Ottobre 2013 si è tenuto il Workshop Internazionale "Science Education and Guidance in schools: the way forward", organizzato da Istituto di Biometeorologia del CNR, Scuola Superiore Sant'Anna di Pisa e Università di Firenze nella elegante location dell'Auditorium di Santa Apollonia a Firenze. Hanno partecipato al workshop circa 70 delegati da 15 paesi, tra Europei ed extraeuropei (Messico, Guatemala, Georgia) e una ventina di ragazzi a rappresentanza di progetti scientifici scolastici basati sull'inquiry (tra cui una classe Acariss, dell'ITIS "Leonardo da Vinci" di Pisa). Sono stati presentati circa 46 lavori tra le sessioni plenarie e la sessione poster. I lavori hanno spaziato dalle metodologie didattiche per l'insegnamento delle discipline scientifiche: scienze naturali, biologia, tematiche sulla sostenibilità ambientale, meteorologia, informatica, oltre che casi di studio pratici sugli ambienti di apprendimento, nonché contributi rivolti alla formazione degli insegnanti. Presto saranno disponibili gli atti del workshop. Per maggiori informazioni rivolgersi a workshop@ibimet.cnr.it

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SCIENCE EDUCATION AND GUIDANCE IN SCHOOLS: THE WAY FORWARD

Scritto da Francesca Ugolini - IBIMET il 19-10-13 01 49

Lunedì e Martedì 21-22 Ottobre presso l'Auditorium Sant'Apollonia - Via San Gallo 25/A, Firenze
[Scarica il file](#)

Figure 2. Picture of the Blog in the ACARISS website.

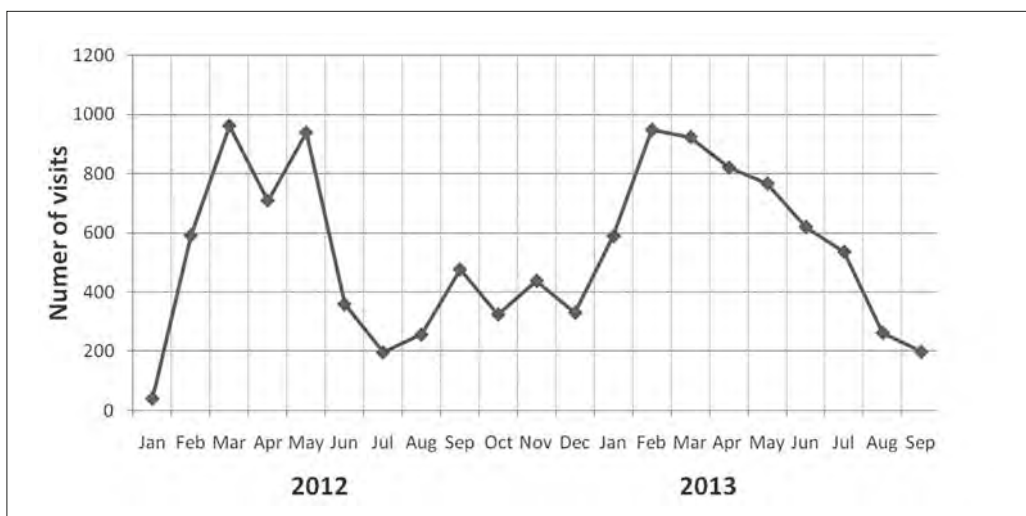
Table 2. Tables with the geographic distribution of the visits.

AREA	NUMBER OF VISITS	PAGES VIEWED	AVERAGE TIME
Province of Pisa	2738	7,74	00:05:47
Province of Florence	2327	6,17	00:04:21
Province of Lucca	812	6,50	00:05:28
Province of Roma	756	4,22	00:03:57
Province of Milano	650	3,70	00:02:56
Province of Livorno	295	3,90	00:02:45
Province of Napoli	176	2,23	00:01:32
Province of Genova	162	3,86	00:02:42
Province of Verona	85	2,38	00:02:36

Results and discussion

One problem with students is that they often fail to connect school learning with outside school experiences and to see the connection with the everyday life activities. Furthermore, students often fail to see how their work is related with other students work. In this context, the website plays an important role in supporting Inquiry Based Science Education and in transforming pure scientific problems in classroom practices. Technology can be viewed as an amplifier of traditional practice or as a transforming agent to support inquiry-based learning. The answers to the central questions: "Will information technology, such as website, have a significant effect on linking student with similar activities?" is positive. We report below (Table 2) some information about how many people linked to web site of ACARISS project. The highest number of visits was recorded in the periods March-May 2012 and February-April 2013, which correspond to the classroom laboratories, while the lowest interactions are shown, obviously, in the summer holiday periods.

The blog, and its structure as a diary, is greatly appreciated by students, which shared their experiences and showed photos and documents; during the two year project, more

**Figure 3.** Distribution of the visits during years 2012-2013

than 150 posts were published. The synergy of cooperative settings triggers motivation more than the individualistic and competitive environments do.

The material produced can be used throughout the national territory, by secondary schools, creating a link among students from different areas. Talk about and around experiments is very important to improve experiences. There are also positive educational effects to this use: students can help each other, and teachers and researchers are encouraged to work together to improve didactic materials. The ease with which students could edit and publish their work made their writing authentic. The feelings of connection produce positive energy towards learning, and the members of cooperative groups learn from one another.

Conclusions

This paper presents a case study that suggests how information technology can support Inquiry Based Science Education. The ACARISS strong point is combining the digital and the experimental aspects. Basically, web tools expand the audience of activities and represent a support for teachers in different geographic areas. Moreover, the use of website applications is an important way to engage students, which are very familiar with this type of tools. Through the website the involvement of the students in training activities is encouraged, the exchange of experiences is increased and the autonomy of participants is supported. The combination of educational innovation and information technology reached the double purpose of facilitating the adoption of training methodology by teachers and to increase the involvement of students, which are attracted by new technologies.

Acknowledgements

This work was realized in the framework of the ACARISS project, funded by the Regione Toscana – PAR FAS 2007-2013, azione 1.1.a.3, Fondo per le Aree Sottoutilizzate, Delibera CIPE 166/2007.

References

- Bybee R.W., Taylor J.A., Gardner A., Van Scotter P., Carlson Powell J., Westbrook A. & Landes N. (2006). *The BSCS 5E Instructional Model: Origins, Effectiveness, and Applications*. BSCS Colorado Springs, CO, USA.
- Rocard M., Csermely P., Jorde D., Lenzen D., Walberg-Henriksson H. & Hemmo V. (2007). *Rocard report, Science Education Now: A New Pedagogy for the Future of Europe*. European Commission.

INQUIRY APPROACH IN ROBOTICS EDUCATION

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Abstract – This work presents a new approach for teaching robotics in high schools with the aim of feeding curiosity in students and of encouraging autonomous exploration. The activity is based on the IBSE method, a constructionist approach focused on the observation of phenomena and on practical experiments. More than 350 junior and high school students were involved in didactic activities, in which they can use robotic kits and software to learn about robotics. In particular, two cases study are presented describing activities in Italian high schools.

Keywords: Educational Robotics, Inquiry Based Science Education, 5E Model.

Introduction

Robotics is considered a subject for specialists, and it is usually taught in universities. Recently, Robotics education has gained a lot of attention in primary and high schools and a great number of initiatives had been developed. Nowadays several types of robotic kits are available, i.e. Lego Mindstorms, developed as an expression of the “constructionist learning” ideas of Papert (Papert, 1991). Despite this wide interest, only few schools in the world have included robotics in their standard *curricula*; in Italy, the country of our study, robotics is taught only in few Technical schools. The aim of the present work is to introduce robotics through a new approach in order to feed students’ curiosity for technology. The proposed activity is based on the IBSE method (Inquiry Based Science Education), encouraged by the European Commission (Rocard, 2007). It is based on the constructionist approach and it is focused on observations of phenomena and practical experiments rather than on theoretical lessons; it is a way to encourage youngsters to be protagonist in problem solving and scientific method rather than passive learners. In this context, robots represent technological artifacts and let the students produce facts, collect data and derive concepts (Demo, 2010).

The ACARISS case study

A two-year study was run in 14 classes of junior (11-13 years old) and senior (14-19 years old) high schools in Tuscany, Italy. A total of 350 students were involved in didactic activities, in which they can use robotic kits and software to learn about the principles behind these technologies. The work included lessons for the students taken by the researchers, training meetings for the school teachers and psychological questionnaires aimed at evaluating the outcomes.

Our approach is based on the 5E model (Bybee, 1997) of the IBSE method, which includes five phases through which the students can approach a scientific problem: Engage, Explore, Explain, Elaborate and Evaluate. This approach well fits with technological education and more specifically with robotics, which supports hands-on experiences and experimental activities. Moreover, robotics is a multidisciplinary subject and allows developing several knowledge and competences.

The activities were adapted on the basis of the *curricula* and of the students' age. In particular, two experiences will be described here: the first was developed in a junior high school, and the second in a senior high school.

The first experience is presented in a first class of junior school (11 years old students) with the Pro-Bot platform, as an example of combining Robotics with Math's *curriculum*. The robot can be programmed manually by a keyboard and can draw a line when it moves. This solution was adopted to study geometric shapes and angles. Students should give the right sequence of instructions (direction, time and rotation angles) in order to design geometric pictures. For example, students tried to write the right instructions to draw the word "ROBOT". This activity supports geometry, Cartesian coordinate system, measurement instruments, ability to sustain opinions on hypothesis and trial and error approach.

The second activity was developed in a 4th class of high school (18 years old students). In this case the experience aims at introducing programming as a connection to informatics subjects. Students were introduced to robot programming by using a Lego Mindstorm platform. They have to build a robot and programming it to do specific tasks. In particular, as final goal, they built a robot that can interact with people in a board game.

In the following part of the paper, a brief description of the different phases is presented for the two experiences.

Engage: The aim of this phase is to feed curiosity and to make connections between past and present learning experiences. Students are faced with the question: "What is a robot?"; a brainstorming is conducted thinking at movies and books, but also introducing real world examples.

Experience 1 and 2: Students observed some small autonomous robots moving in the classroom (Figure 1a, b). The robots react to different stimuli and students try to



Figure 1. Engage phase: a) experience 1; b) experience 2

understand how to interact with them. This is a pleasant way to stimulate curiosity on robot programming and sensors.

Explore: During the Explore learners actively carry on experiments: they are involved in physically assembling and programming a robot and using the on-board sensors (Figure 2a, b).

Experience 1: Students should program a robot, on which it is possible to insert a pen and draw a line on the car path. The robot can be programmed by some buttons on the top of the robot; in particular students can decide the distance, the direction and the angle of rotation of the car. Students are asked to make different designs and shapes.

Experience 2: Students should program a robot to do specific tasks. They decided to create a board game with two teams and a robot that moves left or right depending on which team is getting more points. In particular, students try to give the right command to the robot in order to move it according to the game rules.



Figure 2. Explore phase: a) experience 1; b) experience 2

Explain: The Explain helps students explicate the concepts they have been exploring and lets teachers introduce definitions: students focus their attention on the main components of robots and on the functional principles of sensors and actuators (Figure 3a, b). Students discuss with scientists problems that they have encountered in implementing the experiment.

Experience 1: Students try to reproduce the path of the robot. They calculated the angles of rotation and discussed about the best commands for the robot. Data collected in the previous phase are discussed and students try to build a model that describes the movement of the robot. This phase allows teacher to introduce geometric theorems and mathematical laws.

Experience 2: Students focused on the software programming and on command given to the robot. This phase allows teachers to introduce informatics notions like flux diagrams, “if cycles”, block of instructions and other concept about programming.

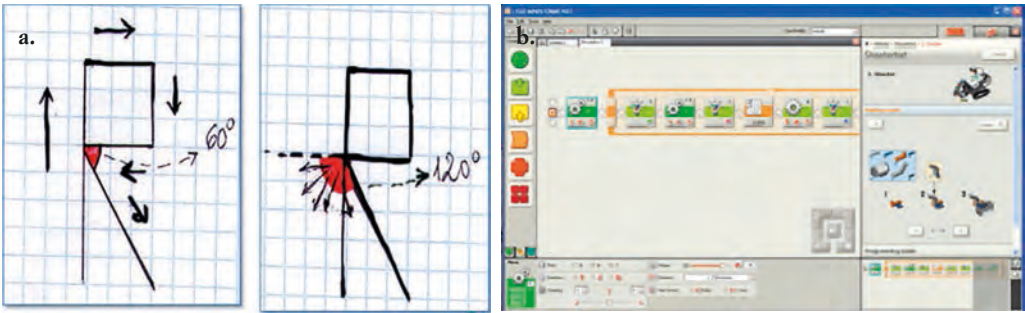


Figure 3. Explain phase: a. experience 1; b. experience 2

Elaborate: In the Elaborate, learners develop deeper understanding of concepts applying the knowledge to new experiences (Figure 4a, b).

Experience 1: Students discussed about the activity results. In particular they tried to apply what they learned with the car to other geometric figures and polygons in order to infer about angles and geometry.

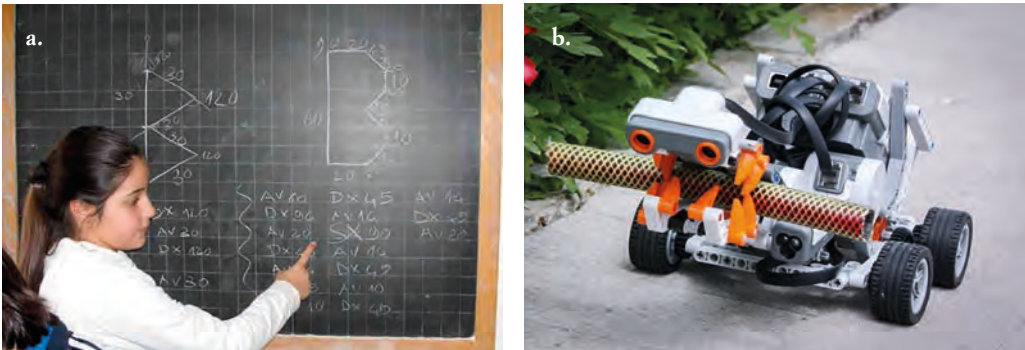


Figure 4. Elaborate phase: a) experience 1; b) experience 2

Experience 2: Students tried to build and program different kind of small robots with different abilities and tasks. In this way they could apply what they have learned in the previous phases to different situations.

Evaluate: Finally, in the Evaluate, learners are encouraged to assess their abilities and lets teachers evaluate students' skill development: the final robots are evaluated, focusing on both the results and the abilities acquired.

Experience 1 and 2: Students presented their work at the final exhibition of the project Acariss. In the first case the car was programmed to write the word "robot". In the second experience the students build a robot with the shape of a crab that "guides" two teams during the board game.



Figure 5. Evaluate phase: a) experience 1; b) experience 2

Conclusions

A method is presented to improve the teaching of robotics. Classes of robotics are carried on in 14 classes following the 5E Model of the IBSE method. This approach gives emphasis to engaging students to concept, feeding their curiosity, encouraging autonomous exploration and experimental activities to discover concepts and theories. Students showed a strong enthusiasm in using robotic tools, thus it could be an effective means to transmit scientific contents. A possible critical point is the need of training programs for teachers, who are often not confident with robotics, in order to reinforce their educational competences with specific technological skills.

Acknowledgment

This work was realized in the framework of the ACARISS project, funded by the Regione Toscana – PAR FAS 2007-2013, azione 1.1.a.3, Fondo per le Aree Sottoutilizzate, Delibera CIPE 166/2007. We would like to thank the teachers Licia Ventavoli of Galilei Institute (Montopoli) and Angela Messina of Liceo XXV Aprile (Pontedera) for the collaboration.

References

- Bybee R.W. (1997). *Achieving scientific literacy: From purposes to practices*. Heinemann, Portsmouth, UK.
- Demo B., Moro M., Pina A. & Arlegui J. (2010). *Discussing about IBSE, Constructivism and Robotics in (and out of the) schools*. Proceedings of Constructionism International Conference, Paris.
- Papert S. & Harel I. (1991). *Constructionism*. Ablex Publishing Corporation.
- Rocard M., Csermely P., Jorde D., Lenzen D., Walberg-Henriksson H. & Hemmo V. (2007). *A Renewed Pedagogy for the Future of Europe*. ISBN 978-92-79-05659-8.

THE EXPERIENCE OF TEACHING MODULE RELATED TO EUTROPHICATION INTO ACARISS PROJECT

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Abstract – The use of direct experiments in the teaching of science stimulates students learning and reasoning. In this paper we describe an Eutrophication didactic module developed by the researcher team of Scuola Superiore Sant'Anna into the framework of ACARISS project that adopted the IBSE (Inquiry Based Science Education) method. More than 120 students from secondary schools of different geographical and socio-economic areas of Tuscany attended the eutrophication module. A strong exchange of experiences between students, autonomy of participants, and problem solving were the main results achieved. In this work the structure of the module and the approaches followed by students is shown.

Keywords: Inquiry based learning, innovative didactic, nutrients, nitrates, science education, phosphates.

Introduction

Experiments in science teaching stimulate students to achieving a better understanding of scientific phenomena. In the frame of ACARISS project (Increasing the knowledge on environment and pollution risks involving schools in experimental activities) the researcher team of Scuola Superiore Sant'Anna developed didactic modules, based on IBSE (Inquiry Based Science Education) method, for teachers of the secondary schools. One of these modules was focused on one of the more widely diffused environmental problems, eutrophication that is defined as “An increase in the rate of supply of organic matter in an ecosystem” (Nixon, 1995).

Objectives of the module were:

1. sensitize the students on the problem of eutrophication of aquatic environments and understand the causes that determine it;



Figure 1. Training course for teachers participating at the eutrophication module in the year 2012/2013.

2. study the relationship between the increase of nitrate and phosphate concentrations in aquatic environments and algal biomass production;
3. become familiar with the procedures necessary for the implementation of the experimental protocols; raise awareness among students of behaviors that reduce or prevent the eutrophication problem.

In order to explain the philosophy of the method and how to deal with the experiments in classroom, teachers training courses at the Polo Sant'Anna Valdera (Pisa) were carried out (Figure 1).

Module development following 5E Model

Our approach is based on the 5E model (Bybee *et al.*, 2006) of the IBSE method, which includes five phases through which the students can approach a scientific problem: Engage, Explore, Explain, Elaborate and Evaluate. More than 120 students of the Secondary school (age 13-17) were involved in practical activities adapting the suggested experiment at their territorial contexts. In particular the water used to test eutrophication was taken near to the place where students live (ie Arno River).

Engagement: *The aim of this phase is to stimulate students curiosity.* Through case studies, teacher deals with the subject of eutrophication of aquifers devoting particular attention to the causes and its environmental consequences.

An example of discussion developed in the classroom between teachers and students can be resumed from the project's blog where students write: *i)* “in classroom we watched with the teacher few pictures related to eutrophication problem, trying to answer some questions about this problem”; *ii)* “at home, we try to understand the causes of eutrophication studying the role of nitrates and phosphates in the environment”; *iii)* after long discussion we develop experiments, in order to replicate eutrophication problem, entering in the core of *exploration* phase.

Exploration: *The aim of this phase is to run experiments.* Peoples are encouraged to actively plan an experimental protocol. They are involved in the preparation of solutions at various concentrations of nitrate and phosphates. Starting from the observation of those nitrates are present in drinking water, students decided to test KNO_3 concentrations as followed in experiment #1 of Table 1. Moreover a combination of nitrates and phosphates were added to water samples coming from different sites in order to develop eutrophication (Table 1 and Figure 2).

EXPERIMENT	KH_2PO_4 (mg L ⁻¹)	KNO_3 (mg L ⁻¹)	LIGHT
#1	0	0-10-20-40	yes/no
#2	0-1.1	20	yes
#3	0-22	200	yes
#4	0-33	400	yes

Table 1. Different variables analyzed on eutrophication experiments.

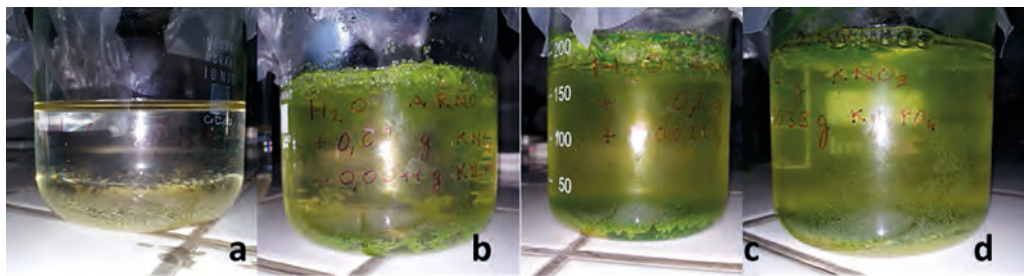


Figure 2. Example of experiment with water added with different nitrate and phosphate concentrations in the light condition. a) control (Arno water); b) 1.1 (mg L^{-1}) KH_2PO_4 and 20 (mg L^{-1}) KNO_3 ; c) 1.1 (mg L^{-1}) KH_2PO_4 and 20 (mg L^{-1}) KNO_3 ; d) 40 (mg L^{-1}) KH_2PO_4 and 33 (mg L^{-1}) KNO_3 .



Figure 3. Example of experiment with water added with different nitrate in dark condition. right to left: control (Arno water); 10 (mg L^{-1}) KNO_3 ; 40 (mg L^{-1}) KNO_3 ; 20 (mg L^{-1}) KNO_3 .

Since light was considered a very important parameter able to induce algae developments, different light condition (yes or no) were also considerate. The students decide to apply this variable in a simple way: closing the beakers with water and nitrates in a dark box for all time of experiments (about 20 days). In this condition algae developments was extremely reduced (Figure 3).

With the help of kits, pupils measured nitrate and phosphate concentrations during all experiments. This step enables to understand the relationship among these nutrients towards algae biomass development (Figure 4). In fact, students note that nitrate and phosphate were reduced at the end of experiments and algae were developed.

Explanation: *The aim of this phase is the explanation of findings.* At the end of experiments data collected during exploration were analyzed and discussed in classroom. The relationship among results of parameters such as algae production, change of water color, pH and the different nitrate and phosphate concentrations were analyzed.

Some results discussed during explanation phase of eutrophication module are reported below:

- “the higher concentrations of nutrients (nitrates and phosphates) induce a greater proliferation of algae”;

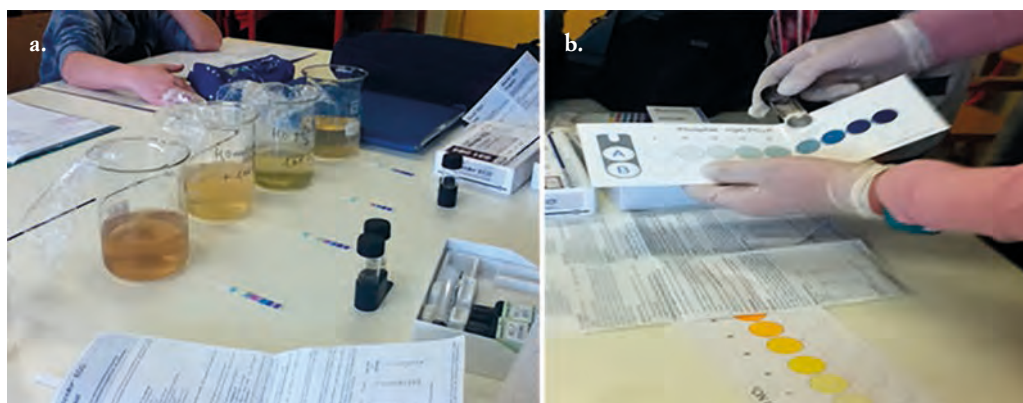


Figure 4. a) Waters samples used during eutrophication module. b) pupil during phosphate analyses.

- “increasing the concentration of both nitrates and phosphates has a synergistic effect on algae growth”;
- “when algae grown fast we note a decrease of the species present (loss of biodiversity);
- “even if in the presence of nutrients algae do not grow in the dark”;
- “a moderate increase of temperature promote eutrophication”;
- “always, when algae are well developed, we note a decrease in the concentration of nutrients and an increase in pH due to consumption of CO_2 ”.

Elaboration: *The aim of this phase is to extend the concepts.* Students and teachers discussed about the algal production under eutrophication. From our point of view data *elaboration* and *explanation* of findings were the most difficult part of the module. In particular, algae identification (Figure 5) was helped by research team in order to explain the concept of biodiversity that was lost during the eutrophication process.

Evaluation: *The aim of the phase is the presentation of results.* Pupils presented their results as poster, power point presentation and participated to photographic contest (Figure 6). In particular, Scuola Sant’Anna organized into the frame of ACARISS project a

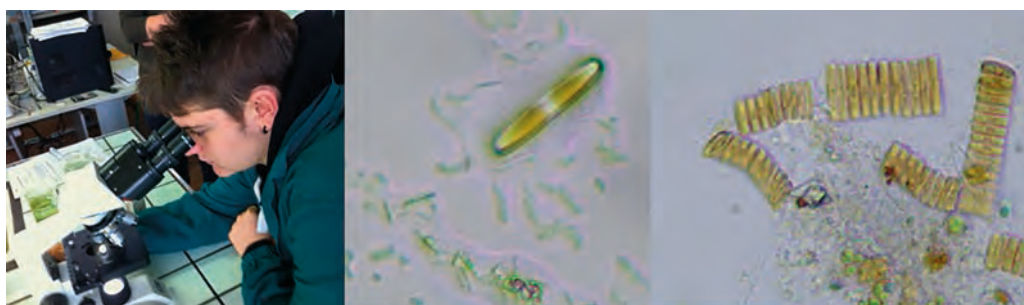


Figure 5. Student during microscopic investigation and two images of algae developed during eutrophication process.



Figure 6. Students exposed their results during ACARISS Workshop at Scuola Superiore Sant'Anna.

Workshop day with all the schools involved in the project. During this final competition, more than 300 students were selected from 45 classrooms, exposing poster, pictures, power point presentations and real experiments results.

Conclusions

The high number of requests to repeat the application of 5E Learning Cycle Instructional Model, used during ACARISS, is a clear demonstration of the success of this project. Specific lessons, conducted by researchers, tools and materials proposed in the project are considered by students as interesting and more attractive than normal curriculum. The practice experiments using scientific inquiry during the teaching process help in fact, students to understand everyday problems and situations such as eutrophication. In these experience, we noticed that students knew what was the algae proliferation process but, they did not know absolutely the causes. After these experience, the teachers declared to be very interested to maintain contact with the researcher staff of our University in order to improve the knowledge of students.

Acknowledgement

We would like to thank all the teachers and students that followed eutrophication module into ACARISS project.

References

- Bybee R.W., Taylor J.A., Gardner A., Van Scotter P., Carlson Powell J., Westbrook A. & Landes N. (2006). *The BSCS 5E Instructional Model: Origins and Effectiveness*. BSCS Colorado Springs.
- Nixon S.W. (1995). Coastal marine eutrophication-A definition, social causes, and future concerns: *Ophelia*, 41, 199-219.

“PLANTS AND SALINITY” A DIDACTICAL MODULE OF THE ACARISS PROJECT

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Abstract – The use of direct experiments in the teaching of science stimulates students learning and reasoning. In this paper we describe a “Plant and Salinity” didactic module developed by the researcher team of Scuola Superiore Sant’Anna into the framework of ACARISS project that adopted the IBSE (Inquiry Based Science Education) method. More than 130 students from secondary schools of different geographical and socio-economic areas of Tuscany attended the plant and salinity module. A strong exchange of experiences between students, autonomy of participants, and problem solving were the main results achieved. In this work the structure of the module and the approaches followed by students are shown.

Keywords: Inquiry based learning, innovative didactic, salt, stress, growth.

Introduction

In the frame of ACARISS project (Increasing the knowledge on environment and pollution risks involving schools in experimental activities), the researcher team of Scuola Superiore Sant’Anna designed four modules in the field of agriculture and environment. One of these, named “Plants and Salinity”, was focused on the understanding of the effects induced by high concentrations of salts in plants.

Plant growth and development are adversely affected by salinity and the sensitivity to salinity varies from one developmental stage to the next (Läuchli and Grattan, 2007). Starting from this statement students were stimulated to collect plants tolerating salinity and to compare the physiological modification of plant organs (leaves, stems and roots) under different levels of salinity stress.

About 130 students of the Secondary school (age 10-14) were involved in practical activities following the Instructional 5E Model (Bybee *et al.*, 2006). Before the activities in the classroom, researchers have carried out teachers training courses at the Polo Sant’Anna Valdera (Pisa) in order to explain the philosophy of the method to the teachers and how to deal with this type of experiments (Figure 1).

The activities proposed to the class took place in collaboration between teachers of secondary schools and Sant’Anna researchers. In fact, the scientific methodology applied was supported by the presence of the scientists in order to give an exhaustive description of the phenomena observed. In the following part of paper, a brief description of different phases of module is presented.



Figure 1. Training course for teachers participating at the plants salinity module in the year 2012/2013.

Engage. *The aim of this phase is to stimulate students curiosity.* Through case studies, teacher deals with the subject of plants that are tolerant or not to salt stress, with particular attention to the plants that are able to live near to the sea. An example of engagement on this contest was reported by students into blog web side of ACARISS project (www.acariss.it). The students writing their experience as followed: “*in classroom we watched with the teacher few pictures related to plants resistant to salt stress named halophytes (plants that naturally grow under high salinity and are therefore tolerant of salt stress). We try to found the physiological differences among plants that are glycophytes (that can not tolerate salt stress). Finally we performed experiments in order to study the salt stress responses on plants and understand the level of resistance among different species of monocotyledons and dicotyledons plants.*”

During this phase the teacher usually divide the class in experimental groups (about five pupils) with the aim to stimulate the groups to run different experiments able to explain the salt stress in plants.

Explore. *The aim of this phase is to run experiments.* Different types of seeds were used during this phase: Soya - *Glycine max* (L.) Merr.; *Vigna* spp. - *Triticum* spp.. During this stage, the students decide to perform their classroom experiments into readily available plastic bottles. Before starts the salt experiments seeds were grown in sand and clay (Figure 2a) and then, different concentrations of salt (NaCl) were added to water used to watering (Figure 2b).

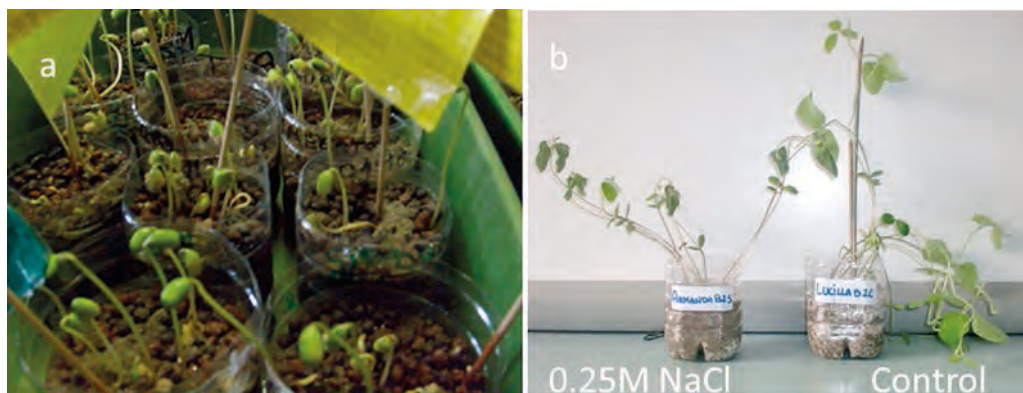


Figure 2. a) Soya seeds grown before start the salt treatments.
b) Soya plants after ten day of treatments 0.25 M NaCl compared to control.

EXPERIMENT	Number		%		gram		cm	
	HEALTHY LEAVES	NECROTIC LEAVES	NECROTIC LEAVES	FW LEAVES	FW STEM	FW ROOTS	STEM LENGTH	ROOTS LENGTH
Treatment NaCl								
Control								

Table 1. Summary table used by students at the end of salt experiments.

With the help of Sant'Anna researchers, at the end of experiments, pupils measured fresh weight, length of plants, length of roots and number of leaves following the instruction reported in Table1. An example of excel data elaboration done by students is reported in Figure 3.

These steps enable students to understand the relationship among NaCl and plant growth under salt stress (Figure 4 and 5).

Explain. *The aim of this phase is the explanation of findings.* At the end of experiments data collected during exploration were analyzed and discussed in classroom. Students were helped in order to explicate the concepts that they have been explored introducing new definitions. The relationship among results of parameters such as change of leaves' color, change of length of plants, NaCl concentration that had determined death of plants, were analyzed.

During this phase students declare in the blog of web site of ACARISS: “we have learned the word chlorosis = process of leaf yellowing; anoxia = absence of oxygen for the plant, caused by excess of water”. Moreover: “our seedlings are grown well, but only those of control; those treated with salt instead are dried and yellowed. The margins of the leaves are necrotic and appeared spots on some leaves”.

Seme A: Soia				Seme B: Vigna paradiso				Seme D: Vigna radiata			
CONTROL	0,25 M	0,5 M	1 M	CONTROL	0,25 M	0,5 M	1 M	CONTR	0,25 M	0,5 M	1 M
FUSTO			MORTA	FUSTO		MORTA	MORTA	FUSTO			
1,5 g	1,2g	/	/	1g	0,8g	/	/	0,625 g	0,75 g	0,45 g	0,1 g
PESO RADICE		/	/	PESO RADICE		/	/	PESO RADICE			
0,5 g	0,5 g	/	/	0,25 g	0,29 g	/	/	0,5 g	0,42 g	0,22 g	0,12 g
PESO FOGLIE		/	/	PESO FOGLIE		/	/	PESO FOGLIE			
1,25 g	1g	/	/	0,25 g	0,3g	/	/	0,5 g	0,3 g	0,15 g	0,05 g

Figure 3. Student data elaboration with excel program.

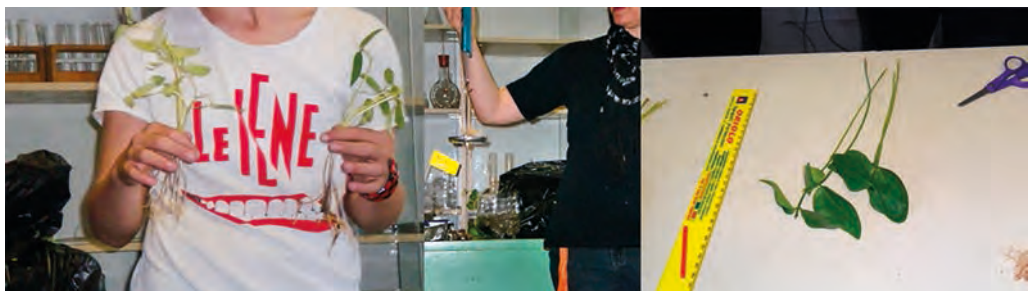


Figure 4. Different steps of plant analyses at the end of salt stress experiments.



Figure 5. *Vigna* spp. plants exposed to 0 (control) 1, 0.5, 0.25 NaCl.

Finally students observed that: “soya plants grown well compared to other species” but the concentration of 0.5 and 1M induced death in these plants (Figure 6).

Elaborate. *The aim of this phase is to extend the concepts.* Pupils and teachers discussed about salt stress. From our point of view data elaboration and explanation of findings were the most difficult part of the module. In particular, we note that students are in trouble when they have to express their opinion about the observations done. Anyway, students clearly understand the role of salt on plant development; in fact declare: “given the observations of this project, be careful plants under salt... Die!!!).

Evaluate. *The aim of the phase is to presentation of results.* Pupils presented their results as poster, power point presentation and participated to photographic contest (Figure 7). In particular, Sant’Anna University organized, into the frame of the project, a “Workshop day” with all the schools that followed the project. More than 300 students were selected



Figure 6. Examples of soya plants after three weeks of grown under water (a) and 0.5 M NaCl (b).



Figure 7. Students exposed their results during ACARISS workshop at Scuola Sant’Anna. On the left the plant salinity experiments is visible.

from 45 classrooms, exposed poster, pictures, power point presentations and real experiments results during this final competition.

Conclusions

Although the module “Plants and Salinity” has been created by researchers of Scuola Sant’Anna only in the years 2012-2013 into ACARISS project, it resulted the most followed into environmental modules developed by our University. In virtue of its easy application, teachers has been completely satisfied by the materials available in the ACARISS web site, because they said they would like to have more specific laboratory protocols and research materials. The teachers also declared to be very interested to maintain contact with the researcher staff of our University in order to improve the knowledge of students.

Acknowledgement

We would like to thank all the teachers and students that followed *Plants and Salinity* module into ACARISS project.

References

- Bybee R.W., Taylor J.A., Gardner A., Van Scotter P., Carlson Powell J., Westbrook A. & Landes N. (2006). *The BSCS 5E Instructional Model: Origins and Effectiveness*. BSCS Colorado Springs.
- Läuchli A. & Grattan S.R. (2007). Plant growth and development under salinity stress. In Jenks M.A. *et al.* (Eds). *Advances in Molecular Breeding Toward Drought and Salt Tolerant Crops*. (pp. 1-32). Springer.

ENGAGE STUDENTS IN THE DESIGN OF SIMULATION MODEL IN ACARISS

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Abstract – The aim of this work is to present a didactic module developed in the framework of the project ACARISS (Increasing the knowledge on environment and risks of pollution involving Schools with experimental activities), funded by Tuscany Region– Italy. Three scientific partners, Institute of Biometeorology-CNR (Florence), Scuola Superiore Sant'Anna (Pisa,) and University of Florence and more than 30 schools in Tuscany cooperated to develop and test modules on several scientific topics (meteorology, climate change, carbon cycle, pollution, plant and salinity, robotics ...). These modules are based on the inquiry based learning method (IBL) and follow the 5E Instructional Model proposed by Bybee et al. (2006). In this method students are stimulated to experiment, observe, investigate on phenomena and find solutions through five steps: Engage, Explore, Explain, Elaborate and Evaluate. Here we present the module on the development and use of simulation models in Biology, since their use can find interesting application on the sustainable use of resources (water for crop irrigation) and reduction of pollutant in agriculture (use of pesticides to fight plant disease). Here the structure of the module and in particular the engagement phase are described. To introduce and raise interest to this topic , students are asked for proposing a solution to the following question: “How long it takes to cross Italy by bike? Where will the biker stop to sleep?”. This question is the opportunity to learn basic concepts of simulation model design through gaming. At the beginning, students are stimulated to identify the main components of a model. They define the output of the model, they identify the factors that might affect the output and select among them those they consider the most important input. Then they propose a model equation that represents relationship between input and output (for example the speed of the bikers). They use their model to predict the distance traveled by the biker each day (simulation). Afterwards, they build a real journey playing a game. based on a dice which determines the effective distance traveled each day by the biker. A low score corresponds to a shorter traveled distance than predicted, to simulate the uncertainty of the prediction due to factors that cannot be considered in the model like a tire puncture or a storm. Then students compare the simulation and the real journey to evaluate the model performance. Finally students discuss their experience and try to elaborate and generalize the fundamental concepts they learnt and apply them to a different context.

Keywords: Inquiry Based Learning, secondary schools, simulation models

ALLIUM CEPA AS AN ENVIRONMENTAL BIOINDICATOR

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Abstract – Many countries of the world are increasing environmental pollution due to industrial development and to little attention given to environmental sustainable production processes; as a consequence, air, water and land contain different pollutant substances that may have negative effects on our health and on other organisms' life. Some of these molecules may have toxic, mutagenic and carcinogenic properties, increasing the health risk for all the organisms. Identifying and characterizing the pollutant species and monitoring the possible sources of pollution are useful actions to guarantee a sustainable management of the environment, a protection of human health and ecosystems.

In our experience we grown root of onion *Allium cepa* L. in three different solutions: *i*) water taken from a tract of the Arno river flowing through the city of Pisa; *ii*) nicotine and benzene solution; *iii*) simple tap water as negative control; *iv*) formalin solution as positive control.

We observed that in positive control (formalin and benzene) and in nicotine sampling roots length was notably smaller compared to the negative control and water of the Arno river. Moreover, roots color was changed in the tested samples (brown) compared to negative control. As regards distortions, breakups, root swellings, they have been greater in the positive control and in the benzene sampling and significantly greater in the nicotine sampling. Under microscopy we try to see the different mitosis phases in root apexes but, we did not manage to notice the presence of micronuclei and/or chromosome aberrations despite the preparation of a certain number of slides. We suppose that this is only a case do to the time of sampling of our samples. We can surely affirm that *Allium cepa* L. is a good bioindicator to establish the potential genotoxicity of various solutions because is easy available throughout the whole year, has low cost, fast rooting and are usable as samples that are not subjected to preparation treatments.

THE MODULE EUTROPHICATION IN THE EXPERIENCE OF ITIS “L. DA VINCI” PISA

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Abstract – In the frame of Acariss project (Increasing the knowledge on environment and pollution risks involving the high schools in experimental activities) the secondary ITIS school L. da Vinci from Pisa participate following the module “Eutrophication”.

This module was applied by students of classes 2A and 3BTA. In particular the water used was taken by the students near to the place where they live.

We reported here the approach that student adopted in order to develop a personal protocol for better understand the environmental problems such as eutrophication. For attempted to relate the production of algal biomass by different parameters different thesis tested on water taken from a tract of the Arno river flowing through the city of Pisa were compared to water course stagnation and distillate water (as control). The variables were adopted were: nitrate or phosphate at different concentration; nitrate plus phosphate; light; temperature and water pH.

The analyses of nitrate, phosphate and pH were performed at each stage (start, after two weeks and after a month). Moreover students observed each sample either with the naked eye or with a microscope in order to evaluate changes of algal production.

INQUIRY BASED LEARNING AND LANDSCAPE APPRECIATION

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Abstract – This paper describes how science education is a powerful tool to understand and appreciate the characteristics of the territory. Two classes of Acariss project were involved in two didactic modules based on IBL and using the 5E Learning Cycle Instructional Model (Bybee *et al.*, 2006). These modules concerned two distinguishing features of the territories around the schools. One class was involved in activities related to the effects of CO₂ natural emissions on plants, whereas the other class activity dealt with soil erosion. Field trip visits to a natural CO₂ spring and a landslide were used to introduce and engage students in these topics.

Observing real phenomena and applying the scientific methodology to represent or investigate them allowed students to raise effectively the interest and the knowledge towards their territory.

Keywords: carbon cycle, CO₂ emissions, Inquiry based learning, modelling, science education, soil erosion

Introduction

The schools Istituto Comprensivo di Capannoli (Pisa) and the Istituto Comprensivo “R. Fucini” in Monteroni d’Arbia (branch in Vescovado di Murlo, Siena) are located in two different rural contexts of the Tuscany Region. The first one is located in the area of Valdera, a wide rolling hills area highly exploited by agriculture, whereas Mediterranean woodlands only cover the steeper slopes. The second school is located near Siena, in an area characterized by isolated farms. Intensive agriculture over the years has been making the land vulnerable to soil erosion, exacerbated by the physical features of the soil.

In the frame of Acariss project (Increasing the knowledge on environment and pollution risks involving the schools in experimental activities) (funded by the Tuscany Region Government, PAR-FAS Funding. Action Line 1.3.a.a.), two scientific didactic modules were created on environmental issues: one on carbon cycle and one on soil erosion. These modules were adapted to these territorial contexts and retailed to the classes, aiming at enhancing the knowledge transfer and territory knowledge of the students which too often do not know the place where they live. The aim of this work is to present the structure of these modules and the outdoor activities that stimulate the interest of the students towards the features of their territory.

Methodology

About 40 students of the Secondary school in Capannoli (Pisa) (age 13) and 14 students of the Secondary school of Murlo (age 14) were involved in practical activities on site and in classroom following the Instructional 5E Model (Bybee *et al.*, 2006). This model applies

five steps to engage pupils on a scientific issue. These phases are:

- *Engagement*, which aims to stimulate curiosity.
- *Exploration* which aims at investigating a phenomenon through experimental activities.
- *Explanation* aims at the explain the findings.
- *Elaboration* which aims to extend the learnt concept
- *Evaluation* which aims to present the results and findings of the activity

Within the module on carbon cycle, the engagement phase took place at a natural spring of CO₂ called “I borboi”, close to Lajatico not far from the school. Natural CO₂ springs are connected to residues of volcanic activity and are important because they provide a valuable opportunity to study long term effects of CO₂ enrichment on natural vegetation. They are also important because they can be considered outdoor scientific laboratories where students can study the environment and its features through direct observation. As well as for Capannoli, the visit to a landslide along the highway connecting Siena to Grosseto, approximately 15 km far from the school, was organized to engage the students of Vescovado di Murlo in soil erosion.

In both cases, field visits aimed to enhance the pupils’ knowledge about the local territory, about how it is exploited, its vulnerabilities but also its peculiarities, and to explain scientifically environmental issues. Field visits were accompanied by experts (geologists, environmental guides, local stakeholders) in order to give an exhaustive description of the area and its concerns.

Field visits were also preliminary to the exploration phase of the module. Pupils were stimulated to represent the phenomena observed in the real context or to investigate further on it. To do this, the scientific methodology was applied, supported by the presence of the scientists.

Results and discussion

Module on carbon cycle with specifics on CO₂ enriched atmosphere effects on vegetation

The module aimed at understanding of scientific peculiarities of the territory by local pupils through experiments and scientific activities concerning CO₂ emissions. The activities carried out in each phase of the 5E Model are reported.

Engagement

Pupils were firstly guided in the landscape reading: they looked around and tried to interpret the landscape and its transformations from the past. They got information about the ancient and modern productive activities and current problematics connected to the land exploitation. Information on Mediterranean vegetation species and woodland management were also given.

Then, the peculiarity of the site was introduced through practical experiments: atmospheric CO₂ was measured before arriving to the Borboi spring (Figure 1). The measurement was repeated at different distances from the CO₂ spring. The values were compared.



Figure 1. Field visit to the CO₂ spring.

On the dirty road, CO₂ was close to 400 ppm, getting closer to the spring, the value raised to 800 ppm till signing error code at the spring. Questions like what kind of effects high CO₂ produces on the vegetation and on humans raised up.

Exploration

In order to answer the questions above, pupils simulated to be scientists. Looking around the spring site, one species (*Mirtus communis*) was selected for further analysis. Two samples of leaves have been analysed: one sample taken from trees close to the spring (CO₂ treatment) and one sample far from it (control). Leaf samples were kept fresh in plastic bags and brought to schools inside a refrigerator bag. For each leaf, leaf area and weights (fresh and dry after drying) (Figure 2) were measured. These data allowed to calculate relative water content and leaf mass per area.

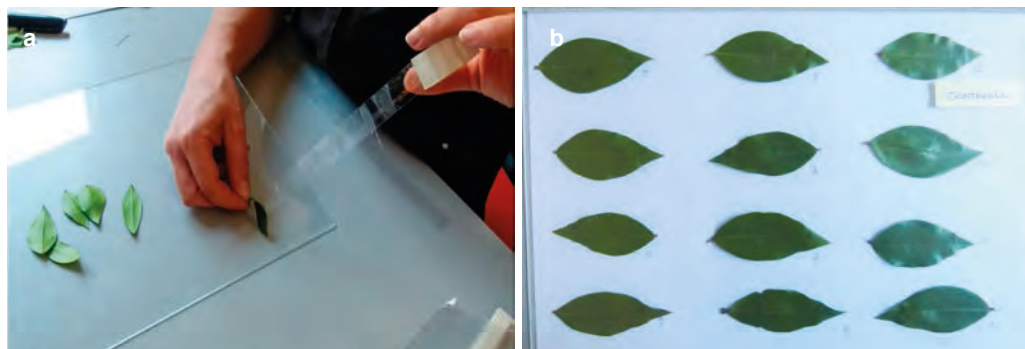


Figure 2a, b. Leaves of *Mirtus communis* taken for analysis (stomatal impressions and leaf parameters).

Explanation

The experiments on sites identified the CO₂ properties while the hands-on activity in classroom dealt with the comparison between leaf samples, leaves of plants grown in high CO₂ and those of plants grown in the control site. The two samples showed different values for leaf area, leaf weights with higher values for control site (Figure 3, Table 1). The effect of high CO₂ is usually specific for one species, for instance tree species like *Quercus ilex* show a reduction of leaf expansion while grasses like *Plantago* spp. show bigger leaves at higher exposures.

Table 1. Results from the investigation on collected leaves.

LEAF PARAMETER	BORBOI	CONTROL
Leaf area (cm ²)	7.2	11.1
Fresh weight (g)	0.16	0.30
Dry weight (g)	0.08	0.14
Leaf mass per area (g/cm ²)	0.01	0.01
Leaf water content (%)	53.0%	52.8%

Elaboration

Pupils and scientists discuss about the atmospheric CO₂ enrichment over the past years and the scientific research results on the effects of CO₂ enriched atmosphere on plants (Figure 4). Some examples of anthropic use of CO₂ enrichment are given like the carbon fertilization inside the greenhouses.

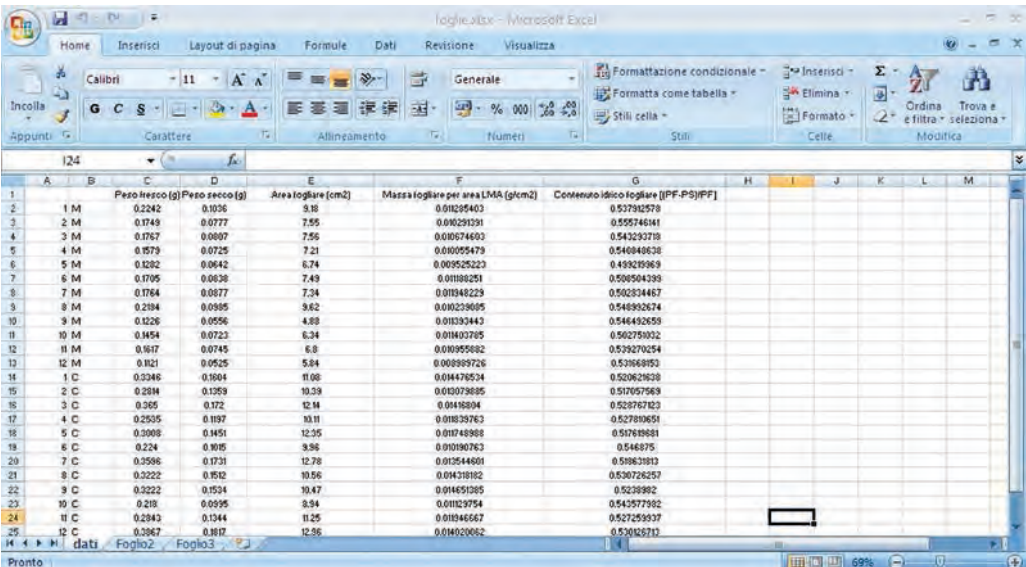


Figure 3. Data of leaf parameters arranged in an excel file.



Figure 4. Example of experimental plan.

Evaluation

Pupils presented their results to the scientist and participated to Acariss photographic contest

The exploration through the field experiments was highly effective for learning purposes. The site is impressive and effective to learn and fix concepts like the properties of CO₂.

Moreover, the availability of scientific results from past studies was helpful to tell students the site-specific relevancies on natural vegetation and the importance of the site for research at international level.

Data elaboration and the explanation of findings were the most difficult parts of the module, although students could approach to the scientist's work.

This module also gave students the possibility to debate in classroom about current concerns regarding for instance the effect of atmospheric CO₂ enrichment, in particular the effects on vegetation of natural ecosystems which have been investigating since the '90 years.

Module on soil erosion.

This module was carried out at the school Istituto Comprensivo in Murlo (Siena).

The module aimed at understanding the environmental issues characterizing the local territory.

Engagement

In this phase a field visit guided students to a recent landslide (Figure 5). They could observe the territory and the landslide, helped by geologists, administrators and scientists. They got information about the morphology of the area and the current problematics connected to the land exploitation. They were also stimulated to indicate the factors (soil properties, vegetation, slope, rain ...) that increase the probability of a landslide.

Moreover, they were stimulated to propose an experiment to investigate the influence of each factor.



Figure 5. Field visit to the landslide.

Exploration

Students designed their experiment (Figure 6). They decided to measure the level of erosion of three types of land cover (two different types of bare soil and one covered by grass). The different types of soils were put on hand-made platforms at three different slopes each. The nine devices are put outdoor during a rain event (on the base of weather forecast) and the quantity of removed soil by the water was measured.



Figure 6. Set up of the experimental activity.

Explanation

Data collected in the previous phase were discussed and students tried to build a model to describe the effect of slope and type of soil on erosion.

Elaboration

Students and scientists discussed about the activity results. In particular students described the problems that they encountered in implementing the experiment (for example the difficulty of forecasting an intense rain event that cause measurable effects on soil).

Evaluation

Pupils presented their work at the final exhibition of the project Acariss in Pisa (Figure 6).

In the module about soil erosion, after the visit to the landslide the teacher and the students were highly stimulated to design and carry out their own experiments to study the effect of soil type and slope on soil erosion. They designed and build nine models to test different combination of these factors and planned to put them outside during a rain event to directly measure and observe soil erosion. After the enthusiasm of creating their models, they also experienced the difficulties of setting-up and measure phenomena in a real scientific research (e.g. rely on weather forecast to choose a rainy day to conduct the experiment)

Even though no specific assessment on the effectiveness of the field trip visits was made, some considerations can be done. Students can observe directly what experts are saying about physical and environmental characteristics of the landscape surrounding them. They are able to link and compare the scientific concepts and information they are provided with what they see in the real world. When vegetation is described they can see in detail



Figure 7. Pupils arrange their stand at the final event in Pisa.

shapes and colors of the part of a plant, but they can also smell it. Furthermore, since they are out of the school and in presence of experts, they are stimulated to ask questions and propose experiments to investigate the phenomenon. Also teachers are surprised and make comments like: who can even imagine that there was such an important scientific site near our school that has been studied by many scientists worldwide. The visit has also important effects on the following steps of the modules. For example in the module of soil erosion, during the field visit students identify the factors causing the landslide and realize the need to build simulation models to understand the phenomenon, comparing different conditions (soil type and slope). Finally, students can study the real and get the theory from the practice. What they are studying is actual and link to the environment, afterwards this knowledge allows them to understand and appreciate more the characteristics of the place where they live

Conclusions

The 5E Learning Cycle Instructional Model, developed in the United States of America, can be surely applied to the Italian school context. According to teachers, this kind of model is successful especially because pupils feel involved in the whole learning process, it raises motivation and is successful in knowledge transfer. The double purpose to learn scientific issues while appreciating own territory is very worthy. Nevertheless, the application of this methodology as well as the learning process require too much time in comparison to the time that can be dedicated to a specific topic of the school curriculum.

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References

Bybee R.W., Taylor J.A., Gardner A., Van Scotter P., Carlson Powell J., Westbrook A. & Landes N. (2006). *The BSCS 5E Instructional Model: Origins and Effectiveness*. BSCS Colorado Springs.

INVITED SPEAKERS

THE EDUCATIONAL ACTIVITIES OF THE EUROPEAN GEOSCIENCES UNION

BEST PRACTICE FOR THE SCIENCE-TEACHING INTERFACE

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Abstract – We report here on the educational activities of the European Geosciences Union (EGU) which are conducted by its Committee on Education. We have focused on workshops dedicated to secondary school teachers, mainly High Schools. From initial workshops held during the General Assemblies of the EGU, a wider program has been developed with teachers' workshops taking place in different countries in connection with EGU Alexander von Humboldt topical conferences series. More than 1000 teachers have attended these workshops, which are a mixture of presentations by worldwide known scientists, hands-on experiences for the classroom and presentations by the teachers themselves to their fellow teachers.

Introduction

In 2002 in Nice, France, EGU Executive Secretary Arne Richter announced a collaboration between scientists and schools all over Europe. The aim was to bring state-of-the-art science via high school teachers into tomorrow's classrooms.

Carlo Laj was appointed chair of the EGU Committee on Education (CoE) and, in 2003, the first GIFT workshop took place at the General Assembly, featuring 42 teachers from seven European countries.

Since then, the Committee on Education of EGU has progressively developed programs and educational materials mainly aimed at secondary school teachers and pupils.

These programs have been developed along 5 main axes:

- 1) Geosciences Information for Teachers (GIFT) workshops at EGU General Assemblies and more recently at Alexander von Humboldt topical Conferences
- 2) Educational sessions at EGU General Assemblies (teachers and scientists and science educators)
- 3) Gift Distinguished Lectures series
- 4) Teachers at sea
- 5) EGU-UNESCO-ESA Collaboration for GIFT workshops in Africa
- 6) Foster collaborations between schools

These activities are briefly described below.

1) *The GIFT workshops at the EGU General Assemblies*

The program of each workshop is focused on a unique general theme, which changes every year, and which combines scientific presentations on current research in the Earth and Space Sciences, given by prominent scientists attending EGU General Assemblies, with hands-on, inquiry-based activities that can be used by the teachers in their classrooms to explain related scientific principles or topics. Also, teachers are welcome to present to their colleagues some aspects of their own « out-of-the program » classroom activities.

The main objective of these workshops is to spread first-hand scientific information to science teachers of primary and secondary schools, significantly shortening the time between discovery and textbook, and to provide the teachers with material that can be directly transported into the classroom. In addition, the full immersion of science teachers in a truly scientific context (EGU General assemblies) and the direct contact with world leading geo-scientists are expected to stimulate curiosity towards scientific research that the teachers will transmit to their pupils.

The value of bringing teachers from several nations together includes the potential for networking and collaborations, the sharing of experiences, and an awareness of science education as it is presented outside their own countries. At all previous EGU GIFT workshops teachers mingled with teachers from outside their own country and had lunch together with the scientists, which provided rich dialogue for all those who participated since the dialogue included ideas about learning, presentation of science content, curriculum ideas... We, therefore, believe that, in addition to their scientific content, the GIFT workshops are of high societal value.

The workshop quickly became known amongst teachers all over the European continent and, in the following years, the number of participants doubled. Due to the importance of the valuable hands-on activities, which require an intimate setting, and the limited space at the conference venue, the maximum number of participants had to be limited to 85. In 2005, the EGU Assembly moved to Vienna, Austria and 80 teachers from 17 countries attended the presentation by Nobel Prize laureate Paul Crutzen at the GIFT workshop.

Today a GIFT workshop typically includes :

- Two and a half days of workshop
- 80 participants from 20 countries (selected from 250-300 applicants)
- 8-9 conferences by worldwide known scientists present at the General Assembly
- 1 half-day practical works with specialized educators
- 1 poster session “Science in tomorrow’s classroom” where teachers are encouraged to present their out-of-the-official-program school activities and which is open to non-teachers participants (in 2012 we have had about 50 posters from the teachers attending the GIFT workshop out of a total of about 65)
- 1 visit to local institutions in Vienna (UNOOSA, IAEA...) (Figure 1)

And each GIFT workshops starts with a visit and an ice-breaker reception at the Vienna Museum of Natural History on the Sunday preceding the workshop.

In the last 5 years these different themes were addressed: Natural Hazards (2013), Water! (2012), Evolution and Biodiversity (2011), Energy and Sustainable Development (2010) (Figure 2), The Earth from Space (2009) this last one in collaboration with the European Space Agency (ESA).



Figure 1. Teachers visiting the United Nations Office for Outer Space Activities (UNOOSA) and experimenting with GPS, during the 2009 GIFT Workshop in Vienna.



Figure 2. A lecture by Jean-François Minster on Sustainable Energy Programs at Total.

All the expenses for the selected teachers (travel, lodging and registration at the GA) are met by the organization.

The year 2009 brought further additions to the GIFT concept. For the first time, selected lectures were filmed during the workshop. Along with all the other workshop material (programs, brochures, abstracts of presentations) these recordings were made available as web streams and are openly accessible free of charge via the EGU website:

<http://www.egu.eu/outreach/gift/workshops/>

Also, in 2010, the Committee on Education decided to hold a « local » GIFT workshop associated with EGU Alexander von Humboldt Topical Conferences. These are a series of meetings held outside of Europe, in particular in South America, Africa or Asia, on selected topics of geosciences with a socio-economic impact for regions on these continents, jointly organized with the scientists and their institutes/institutions of these regions.



Figure 3. Teachers during a practical exercise at the GIFT workshop in Merida. The Minister of Education of the State of Yucatan, Mr. Raoul Godoy (on the right) attended the GIFT workshop!



Figure 4. Sally Soria-Dengg (standing at left) instructs Peruvian teachers during the GIFT workshop in Cusco.

The first GIFT-AvH took place in Merida (Yucatan), the second in Penang (Malay) the third in Cusco (Peru) (Figures 3). Each time we have had a participation of 40-45 « local » teachers. Noticeably, in the three cases it was the first workshop of the kind organized ever.

2) Educational sessions at the EGU General Assembly.

We regularly organize 8-10 educational sessions during the General Assembly. On of these sessions, mentioned above, « Sciences in tomorrow's classroom » is open to both teachers attending the GIFT workshop and to scientists with an interest in education attending the General Assembly (Figure 5). A growing interest has been shown in Vienna, with over 60 posters presentations, 2/3 by teachers and 1/3 by scientists.



Figure 5. Explaining Energy Saving to fellow teachers! Angela (USA) and Hélder (Portugal) in front of their poster.

3) *The GIFT Distinguished Lecture Series*

In 2011, the EGU Committee on Education has inaugurated an annual series of Geosciences Information for Teachers (GIFT) Distinguished Lectures, to be given by top scientists who have previously participated as speakers in GIFT workshops during EGU General Assemblies. High school teachers, high school directors and educators for teachers from the European area are welcome to ask for a GIFT distinguished Lecture!

Distinguished lectures have been given in Spain, Poland and next (2013-2014) in France and Spain.

4) *The « Teachers at Sea » Program*

“Teachers at sea” is an Educational Program making it possible for high school teachers to participate to oceanographic cruises together with the scientists.



Figure 6. Teachers on board the Marion Dufresne during the AMOCINT Oceanographic cruise in the North Atlantic (Hélder, Angela, Gertrud, Catalina Jean, and Carlo in the background).

3 editions of this program have taken place on board the Marion Dufresne during cruises PACHIDERME in 2007 (along the Coast and in the fiords of Southern Chile), AMOCINT in 2008 (in the North Atlantic Ocean) and CIRCEA (in the South China Sea in 2012) (Figure 6).

On board, teachers participate to the “watches” which is really absolutely necessary for them to be in direct contact with the scientists and students and to be totally immersed in the different activities taking place on board, not only for watching the different coring operations, but also to actively participate personally to the first steps of treatment of the cores: cutting, opening, archiving, measurements of some of their physical properties and of their sedimentological description.

Part of the sediments is saved for the schools, and can be mailed to the different teachers asking for them.

5) 2014: GIFT goes to Africa! (An EGU-UNESCO-ESA Program)

The upcoming year will bring new and fascinating prospects for GIFT. The EGU has teamed up with UNESCO to take the GIFT workshop idea to Africa. ESA has more recently joined this program. The scope is to disseminate the latest findings in science to the teachers there, to support the development of the next generation of Earth scientists in Africa. The opportunities and challenges in the Earth sciences there are great, starting with traditional mineral extraction and extending into environmental

management such as climate change adaptation, prevention of natural hazards, and ensuring access to drinking water. The first UNESCO-GIFT-ESA workshop on African soil will deal with climate change and human adaptation. It will take place at the African Earth Observatory Network at the Nelson Mandela Metropolitan University in Port Elisabeth, South Africa in partnership with the African Center from Climate and Earth System Science and organized by UNESCO’s Windhoek office.

6) Fostering collaborations between schools

As the number of applicants significantly increased, teachers started to form teachers’ networks beyond their national borders. A regular exchange of teachers is now established and is progressing every year.

(<http://www.egu.eu/outreach/gift/>)

ENHANCING STUDENTS' PARTICIPATION IN THE SCIENTIFIC DEBATE

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Abstract – The contribution of pedagogues and philosophers of education recently stresses the importance of developing techniques for stimulating students' intrinsic motivation in learning science and participating in the scientific debate. Among other methodologies, inquiry-based science education (IBSE) has been acknowledged as a great potential to the development of scientific reasoning and to the related competences. The present paper describes some proposals of the research group “Science Communication and Education” of the CNR inspired by the IBSE principles but enriched by some peculiarities aimed at enhancing students' participation in the scientific debate.

Keywords: participative methodologies, post-normal science, science education, scientific debate

Introduction

Motivating students to science learning

In recent years, many scholars (philosophers, educators, teachers) converge towards the need to develop educational strategies that can stimulate the intrinsic motivation of students who are learning science and the importance of allowing them to participate in the public debate (Kachan *et al.*, 2006; Brenneman and Louro, 2008; Howes *et al.*, 2009; Murcia, 2009).

These strategies are officially recognized in the teaching method based on the “inquiry-based science education” (IBSE), as defined by authors such as Duschl (1990), Flick (2004) and Moje *et al.* (2001). Such a method can stimulate rational and critical thinking in students, develop skills that enable them to investigate, select the sources of documentation, analyze a scientific problem, form personal opinions, seek solutions and not simply hold to the original pre-established formulas, and do everything in close contact with the scientific community thus helping to bridge the gap between schools and research centres (Murcia, 2009, De Haan, 2008). In addition, some authors propose teaching practices that encourage teachers to promote the ability to “argue” for students (Jimenez and Erduran, 2008; Driver *et al.* 2000; Duschl and Osborne, 2002; Kuhn, 1993). This approach implicitly recognizes the “complexity” of the nature of modern science and encourages teachers to develop, in science education, «several alternatives to face the same problem, and students to consider and evaluate the evidence and the argumentation of each of the possible solutions» (Osborne, 2005).

These new methods can be effective both if we want to achieve a «science for all citizens», as claimed by Millar and Osborne (1998), or if we want to invest in human capital,

the “Human resources for S&T” as claimed by others (European Commission, 2004).

In addition, IBSE methodologies are also considered important for teacher training. The Talis-OECD report of 2009 has investigated the teachers’ awareness of the role and the influence they have on students’ education and the difficulties they encounter in their work. The result is that some nations have, as one of the difficulties, a lack of pedagogical skills. 42% of all teachers already declared that the reason they do not require additional training is not only a lack of time but also a lack of adequate support. «Relatively few teachers participate in the kind of training that would seem to have a greater impact on their work; such as certification programs and individual research collaboration» (Gurría, 2009). In most countries, teachers say they use traditional methods to convey knowledge in structured situations rather than to develop techniques to respond and adapt teaching to individual needs; far fewer teachers resort to teaching activities which involve a deeper intellectual engagement by of students (OECD, 2009).

These results and other related ones such as, for example, the awareness that the education system – in particular through the textbooks and classroom instruction – participates in the formation of future citizens not only promoting knowledge but also attitudes and values (OECD, 2009), reinforce the conviction that the IBSE methodologies should focus on both teachers and students.

*Communicating science at school using information and participation models:
the CNR proposal*

The theoretical approaches mentioned above have been tested in different school contexts within two Projects, “PAS – Ethics and Polemics” (Valente 2001 and 2009) carried out by the research group “Science Communication and Education” of the Italian National Research Council (CNR) with the collaboration of the British Council, and “Junior Science Café” (Belmonte and Castellani 2012; Pacini *et al.*, 2012) by formaScienza, with the collaboration of Caffè Scienza of Florence.

The methodology of the project proposed by the CNR has been selected as one of the two Italian good practices by the European project Form-it (<http://www.form-it.eu/index.htm>), which analyzed 160 European proposals, with the intent of creating a set of quality criteria and guidelines to carry out research projects and educational cooperation and to produce documents for policy makers. http://www.form-it.eu/goodpractice/projects/ethics_and_polemics.shtml.

Moreover, the methodology of the Junior Science Café has been included in the guidelines for schools developed by the European project SciCafe. Both of these projects propose a path in which students start from a problem (chosen by students or teachers), discuss among peers and acting a co-operative learning, proceed to a phase of documentation where they learn to select and interpret sources, choose and finally confront publicly with experts on the topic. The IBSE methods described above are then enriched by several peculiarities.

– they take into account the *complexity of science* in the sense described, among others, by Latour (1998) as science in process and by Funtowicz and Ravetz (1999) as post-normal, uncertain science: features of modern science, often underestimated in science education, but that have been considered increasingly important in recent years. The growing awareness of the complexity of modern science makes the traditional approach in science communication, often linear, one-way, inadequate to represent the richness and articulation of the relationship science-society;

- they focus on *participatory methods* and cooperation by all actors involved in public debate on science: teachers, students, experts, stakeholders and authorities involved in various ways in the theme. A way to reduce the gap between science and society and to follow what Jasanoff (2003) calls the “participatory turn”, that is that “participatory turning point” involving teachers and students in a process of cooperative learning that makes them feel and be active in the scientific debate (Midoro, 1994). The participatory methodologies, such as the Metaplan (Mayer and Valente, 2009) and the Open Space Technology (Del Grosso et al., 2009) are used to bring out the “tacit knowledge” of students as defined by Polanyi (1967), and as a basis for shared proposals within the groups. This process builds what Ziman (1967) defines as the “collective wisdom”, but also mobilizes different types of competencies and skills that are not typically required at school, nor valued, such as the role of facilitator within the group, the communication skills, the ability to express ideas, the social skills (OECD, 2005). In addition, participatory methodologies are also used in order to redefine the role of the teacher who, besides acting as a facilitator, reflects on his/her practice, acts as a “reflexive practitioner” (Lisle, 2000).
- they promote an approach to knowledge that begins with a *scientific documentation* which makes an extensive use of ICT, but which also meets strict criteria: reliability and diversity of sources, pluralism of opinions and points of view of technical-scientific and social actors involved, both nationally and internationally (Libutti and Valente, 2006). All this is in line with criteria which Fishkin (2004), expert in theories and practices of democracy, considers the starting point of any deliberative process. The goal is to develop skills able to attract young people to issues of science, and to show that inquiring and asking questions is as or more important than learning how to give answers. In particular, the focus is on the importance of bringing students closer to a true culture of information, helping them to become “information literate” (defined by the American Library Association as “the ability to know when information is needed and to be able to identify, locate and effectively use information for lifelong learning and problem solving) as young as possible.

Conclusions

In addition to proposing and testing new models of communication, the CNR group always carries out surveys, using both quantitative and qualitative methodologies, aimed at investigating the perceptions of science and its values and to develop better science communication and education methodologies. (Valente, 2009). Generally two questionnaires are submitted to students and teachers at the beginning and at the end of the Project. What emerges from the inquiries? Here we report just some hints from the general results.

Considering the relation between the students and the experts results revealed that young people are increasingly asking to be protagonists in the process of learning and constructing knowledge. When dealing with complex and global issues, such as climate change, water crisis, GMO, discussed during the debate, students ask to understand the connection between the scientific culture, to which we want them to approach, and the possibility to act in the first person, on a “local” scale, to answer such questions. They feel great pleasure when they discover they also have a sort of knowledge (even if “tacit”) of

such topics, and they can trace the deepest “motivation” that links them to issues which they apparently do not seem to have any relationship with. Students seem to appreciate very much the direct contact with experts and think communication be not only a transmission of facts but also a sharing of theories, knowledge and approaches.

Furthermore, a strong link between scientific culture (not intended in its disciplinary classifications) and civic culture also emerges from the results of the inquiries and from the answers of both students and teachers. In particular, there seems to be a request to consider the “status” of a student and a teacher, related to their institutional role at school, as strongly connected to the identities that refer to other “status” they also belong to, such as age, sex, nationality, social conditions, etc.

Students also ask to find a connection between what they study, discuss and debate at school and what they experience in their everyday life. That is, between inside and outside the school, the subjective and emotional sides of experience, the knowledge acquired at school with that coming from other contexts (different family traditions, media, virtual world, lifestyles, etc.). Such a link is perhaps still too implicit and undervalued at school, whereas it can become evident within an effective practice of public communication by all actors of science communication: museums, schools, scientific institutions, etc.

References

- Belmonte C. & Castellani T. (2012). The ‘Caffè Scienza Junior’ project: Students protagonists of their scientific training. In Koulouris, P. (Ed.), *SciCafé 2012 Conference and Events: Europe’s Science Cafés Thinking Forward. Book of Proceedings*. Epinioa, Athens
- Brenneman K. & Louro I.F. 2008. Science journals in the preschool classroom. *Early Childhood Education Journal*, 36, 113-119.
- De Haan G. & Huck J. (2008). *Recommendations for Policy makers, Form-it. Take part on research project, 6° European Framework Programme. Austrian Institute of Ecology*. Available at: <http://www.form-it.eu/goodpractice/countries.shtml>
- Driver R., Newton P. & Osborne J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education*, 84, 287-312.
- Duschl R. (1990). *Restructuring Science Education. The importance of theories and their development*. Teachers College Press, Columbia University New York – London economy and society directorate. EUR 22700. Brussels.
- Duschl R. & Osborne J. (2002). Supporting and Promoting Argumentation Discourse in Science Education. *Studies in Science Education*, 38: 39-72.
- Del Grosso E., L’Astorina A. & Valente A. (2009). Introducing Open Space Technology in schools to educate towards citizenship in science and society. In Valente A. (Ed.). *Science perception and participation* (pp. 57-68) Biblink editori, Roma.
- European Commission, DG Science and Society (2004). *Europe Needs More Scientists*. Report by the High Level Group on Increasing Human Resources for Science and Technology in Europe.
- Fishkin J.S. (2004). Il sondaggio deliberativo, come e perché funziona. In Bosetti, G. & Maffettone F. (Eds.). *Democrazia deliberativa: cos’è?* (pp. 25-76). Luiss University Press, Roma.
- Flick L. & Lederman N.G. (2004). *Scientific inquiry and nature of science*. Springer, New York.
- Funtowicz S. & Ravetz J. (1999). *Post-Normal Science – an insight now maturing. Futures*.

- Gurria A. (2009). *Remarks delivered at the launch of the OECD Teaching and Learning International Survey (TALIS)*. Mexico, 16 June 2009.
- Howes E.V., Lim M. & Campos J. 2009. *Journeys Into Inquiry-Based Elementary Science: Literacy Practices, Questioning, and Empirical Study*. DOI 10.1002/sce.20297. Published online 21 July 2008 in Wiley InterScience (www.interscience.wiley.com).
- Jasanoff S. (2003). Technologies of humility: Citizens participation in governing science. *Minerva*, 41 (3), 223-244.
- Jimenez-Aleixandre M.P. & Erduran S. (2008). *Argumentation in Science Education*. Springer, The Netherlands.
- Kachan M., Guilbert S. & Bisanz G. (2006). Do teachers ask students to read news in secondary science? Evidence from the Canadian context. *Science Education*, 90 (3), 496-521.
- Kuhn D. (1993). Science as argument: implications for teaching and learning scientific thinking. *Science Education*, 77 (3), 319-337.
- Latour B. (1998). *La scienza in azione*. Edizioni di Comunità, Torino.
- Lisle A.M. (2000). All hail reflexivity. *Annual Review of Critical Psychology*, 2, 109-129.
- Mayer M. & Valente A. (2009). Expressing oneself in order to participate: tacit knowledge, learning and the Metaplan. In Valente A. (Ed.). *Science perception and participation*. (pp. 43-56). Biblink, Roma.
- Midoro, V. (1994). Per una definizione di apprendimento cooperativo. TD. *Tecnologie Didattiche*, 4. Menabò, Ortona.
- Millar R. & Osborne J. (1998). *Beyond 2000: Science Education for the Future London*. King's College London.
- Moje E., Collazo T., Carrillo R. & Marx R. (2001). "Maestro, what is 'quality'?" Language, literacy and discourse in project-based science. *Journal of Research in Science Teaching*, 38 (4), 469-498.
- Murcia K. (2009). Re-thinking the Development of Scientific Literacy Through a Rope Metaphor. *Research in Science Education*, 39(2), 215-229.
- OECD (2005). *The definition and Selection of key Competencies (DeSeCo)*. Executive summary.
- OECD (2009). *Creating Effective Teaching and Learning Environments: First Results from TALIS*. Available at: <http://www.oecd.org/dataoecd/17/51/43023606.pdf>
- Osborne J. (2005). The role of Argument in Science Education. In Boersma, Goedhart, De Jong, Eijkelhogs (Eds). *Research and the Quality of Science Education*. Springer, The Netherlands.
- Pacini G., Bagnoli F., Belmonte C. & Castellani T. (2012). Science is ready, serve it! Dissemination of Science through Science Cafè. In Bucchi M. & Trench B. (Eds). *Quality, Honesty and Beauty in Science and Technology Communication*. PCST 2012 Book of papers. Observa Science in Society.
- Polanyi M. (1967). *The Tacit Dimension*. Anchor Books, New York.
- Valente A. (2001). *Trasmissione d'élite o accesso alle conoscenze?* Franco Angeli
- Valente A. (2009). *Immagini di scienza e pratiche di partecipazione*. Biblink, Roma.
- Ziman J.M. (1967). *Public Knowledge: An Essay Concerning the Social Dimension of Science*. Cambridge University Press, Cambridge, UK.

DESIRE: DISSEMINATING EDUCATIONAL SCIENCE, INNOVATION AND RESEARCH IN EUROPE.

A EUROPEAN PROJECT INVESTIGATES ON HOW SCIENCE INFORMATION CAN BE COMMUNICATED AND DISSEMINATED TO TEACHERS IN AN EFFECTIVE WAY

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Abstract – The paper illustrates the research activities carried out by the European DESIRE project dealing with dissemination strategies of European projects outcomes and results and takes into account specific stakeholders in the projects life cycle. Preliminary findings are given and commented and some recommendations are drawn based on data collected so far.

Keywords: communication strategies, dissemination activities, European dimension, knowledge sharing, science information, science projects

Introduction

The DESIRE project (Disseminating Educational Science, Innovation and Research in Europe) (<http://desire.eun.org/>) develops models of diffusion and exploitation to ease the spreading of science education projects results to teachers. The project started in December 2011 and will end in November 2013. The DESIRE project is carried out by European Schoolnet (EUN) (<http://www.eun.org/>) together with, INDIRE (<http://www.indire.it/>), CRECIM - Universitat Autònoma de Barcelona (UAB) (<http://www.crecim.cat/portal/>), Dansk Naturvidenskabsformidling (<http://www.formidling.dk/>) and Ecsite, the European Network of Science Centres and Museums (<http://www.ecsite.eu/>), and is funded under the European Commission's Lifelong Learning Programme (DG Education and Culture).

The primary objective is to identify how new project results on methods and practices in science education can reach teachers and schools more efficiently.

The main data collection activities so far have been questionnaires and Online Discussion Events (ODE), both of them targeting at different stakeholders in the science communication lifecycle, namely: science teachers, science project planners, policy-makers and organizers of science events, activities and expositions in museums.

Methodology

Project fundamentals

A. Background research

Many dissemination methods have been identified by previous European projects in order to communicate best practices in science education, such as awareness raising

campaigns, panels of pedagogical experts, online teacher training material, learning resource exchange portals, mainly having an Open Education Resource (OER) approach, as defined by UNESCO (<http://www.unesco.org/new/en/communication-and-information/access-to-knowledge/open-educational-resources/>).

Each model has strengths but several obstacles can be highlighted. One of the major problems is, on the one hand, the “cognitive” or “information overload” teachers are exposed since there are large amounts of information available in the Web; on the other hand, teachers often feel that selecting among those resources is actually not part of their ordinary job but more a kind of voluntary activity. In a technical note by the European Commission (2010) dealing with European teachers’ vision, it is clearly stated that one of major digital competences teachers and students have to develop as part of the Europe 2020 strategy is «judging the relevance and trustworthiness of sources and avoiding knowledge overload» (http://ec.europa.eu/research/social-sciences/pdf/communicating-research_en.pdf).

Another problem is that in many countries, school communication is rather hierarchical: head teachers are informed about science projects but do not always share the information they come across to all the school teachers, a problem identified by the knowledge sharing in education strand of research and dealt with by OECD in a recent Toolkit (OECD, 2009) for improving school leadership (<http://www.oecd.org/edu/school/44339174.pdf>).

Finally, another obstacle that can be identified is that many science teaching material is on the use of ICT whilst teachers, especially new teachers, search for pedagogy advice and teaching methodology material, being ICT infrastructure not always available in their classrooms. A report by the Commission, addressed to policy makers (JRCI-PTS, 2010), underlines that the primary teachers’ requirement is, apart from formal in-service training programs, the possibility of «accessing knowledge through exchange between new and experienced teachers» and of counting on expert professionals such as mentors or expert peers and on collaborative learning environments (JRCI-PTS, 2010).

Recently, the European Commission (2012) published a paper on which part of the analysis framework definition was based. The text titled “Communicating EU Research and Innovation: a Guide for project participants” (DGEC, 2010) was considered as a very relevant reference material by the project Consortium who will feed the recommendations by the Commission into the DESIRE project final deliverable.

B. Projects connected

The DESIRE project is building its knowledge and evidence taking into account many European projects on science education, such as SCIENTIX (<http://scientix.eu/>), XPLO-RA (<http://www.xplora.org/>), inGenius (<http://www.ingenious-science.eu/web/guest/about/>) just to mention some and, in a more general sense, the dissemination and communication strategies put in place to reach the intended targets by EUN, running dozens of projects at an international level, and by its network of 30 Ministries of Education (MoE) running projects at national and regional level. All these previous practices were taken into account as a basis for further research and discussion with relevant stakeholders.

THE PROJECT MILESTONES

The first part of the project was dedicated to research activities, data collection and analysis concerning different dissemination strategies used within European projects, especially Life Long Learning (LLP) Projects; to analyze the impact among science teachers

of these methods; to analyze the uptake of project results by policy makers; to propose changes, improvements and new methods to disseminate results and discuss with relevant stakeholders.

In order to gather qualitative and quantitative feedback to propose new dissemination strategies, the project Consortium identified two main methods: questionnaires targeted at the four main stakeholder groups involved in the dissemination lifecycle and discussion events with those target groups (namely science teachers, science project planners, policy-makers and organizers of science events and of activities and expositions in museums).

C. Analysis framework definition

Generally speaking, “dissemination” means spreading something widely, promulgating extensively, broadcasting or dispersing. In a more narrow definition, it can be defined as the “process of sharing information and knowledge, ensuring the physical availability of materials to the target audience and making results comprehensible to those who receive them”. It was also discussed whether dissemination basically consisted of sending information to an audience, without necessary direct contact with the receiver, and without a direct response method and whether “dissemination” was considered the same as “divulgence” or “popularization”. The Consortium came to an operational definition within the DESIRE project as follows, based on Harmsworth *et al.* definition (2000) (<http://www.scientix.eu/>) “We will refer to dissemination as the process by which, using certain strategies, results of a project are made available, comprehensible and usable to be adopted by potential users”. In particular, the Consortium found it useful the definition in relation to the objectives that dissemination can have, or “dissemination for awareness”, “dissemination for understanding” and “dissemination for action”, since it offers a systemic view of dissemination strategies purposes.

D. Dissemination barriers and facilitators

Some dissemination obstacles were identified based on previous EU project experiences and literature, mainly: Institutions’ low priority to wider dissemination; project coordinators and other participants’ practical difficulties (e.g. time constraints); gap between research and policy (driven by different incentives, different timeframes for action, different standards for evidence, style and media typically used by researchers); technical and infrastructural barriers for the users of information accessing information; barriers regarding the format, length, style or approach, content and language in which results are presented; other structural constraints that avoid information reaching the target audience and being understood by them (e.g. time and resource limits, evaluation requests, extension of national programs).

As for the facilitators, the project identified the following ones: incorporating the types and levels of knowledge needed into the forms and language preferred by the user; combining dissemination methods; including information that users have identified as important, and information that users may not know to request but that they are likely to need; taking advantage of existing resources, relationships, and networks to the maximum extent possible while building new resources as needed by users; implementing effective quality control mechanisms to assure that information to be included is accurate, relevant, and representative; establishing linkages to resources that may be needed to implement the information – usually referred to as technical assistance.

The following table 1 was used as a schema to discuss with relevant stakeholders and to design questionnaire items and discussion statements.

Table 1. Dissemination strategies schema.

DISSEMINATION STRATEGIES AND THEIR ADVANTAGES/DISADVANTAGES		
STRATEGIES	ADVANTAGES	DISADVANTAGES
Sharing project working documents	Research findings to particular groups	Limited audience
Sharing research reports	Single reference point	Limited audience
Publishing in academic journals	Reaching scientific community	Limited audience
Publishing in professional journals	Practitioner-oriented audience	Lack of scientific rigor
Using mass media channels	Wide audience reached	Superficial message
Using Internet / emails	Immediacy Networking Low expenses	Uncontrolled potential Risk of overload
Printing brief documents with core ideas	Declare core issues	Limited audience
Producing training material	Applied knowledge	Expenses Limited audience
Using social networks/media	Networking Interaction Exploitation	Time-consuming Low active engagement
Selecting intermediaries	Locally supported	Needs for engagement and agreement Time-consuming
Using participatory techniques	High potential for application	Time-consuming Limited audience

Based on the above framework definition, the project partners proceeded in gathering qualitative and quantitative data.

Data collection methods

As presented above, both qualitative and quantitative tools were used by all partners in their countries.

E. Questionnaires to relevant stakeholders

Questionnaires items were prepared by CRECIM (UAB). Each partner contacted a number of stakeholders, according to stakeholder group, presented the research objectives and invited them to fill in the corresponding questionnaire. Questionnaires were meant to gather quantitative data even though some open-ended questions were provided to capture some qualitative feedback as well. Questionnaires were translated into several Member States languages, namely French, German, Portuguese, Danish, Greek, Spanish, Italian, Romanian and Polish. A pilot testing of the questionnaire was also done before administration. Online questionnaires were then administered online by using the Survey Monkey tool.

F. Discussion events

Discussion events were the main qualitative data collection tools identified. Discussion events were held in different formats, according to technological tools available and to audience specificities. There have been three main formats:

1. *Online platform for discussion*: the project set up a platform (mainly a forum with some instant messaging capabilities) to run online three-day workshops on a specific theme connected with dissemination strategies. Each partner used this modality at least once. So far, two such events were organized for teachers, one for policy makers, two for project managers, two for science museums organizers and one for science events organizers.
2. *One-hour session seminar*: as an alternative to the previous mode described, partners organized shorter seminars having a more focussed approach where the moderator of the discussion would have asked, in turn, to all participants to express their views on a series of issues relevant for the project. The tools used were Google hangouts, Skype conference calls, LinkedIn Groups, and Adobe Connect platform facilities. So far, one such event was organized for science events organizers and one for science museums organizers.
3. *Face-to-face meetings*: meetings and seminars were also organized, often in connection with other projects dealing with science education or having a relevant target group involved. Within these meetings, a one-and-half session was organized to gather participants' feedback and to get useful ideas for successful dissemination strategies. So far, one such event was organized for teachers and one for policy makers.

Through discussion events, the project has so far contacted over one hundred science teachers, twenty science events and museum organizers, twenty policy makers and eighteen project managers.

Results

Different questionnaires about dissemination were designed and administered to relevant stakeholders involved at different levels in projects funded by the EC (7th Framework Programme), by the EACEA (Lifelong Learning Programme) or by other institutions, such as ministries of education of different countries, public or private organisms or societies. In particular, 45 science education projects were selected and various professionals dealing with the project were contacted to invite them to complete the questionnaire. Table 2 shows the list of projects in which the contacted professionals were involved.

G. Questionnaires analysis

Questionnaires are referenced below as Q1 (to project managers), Q2 (to teachers) and Q3 (to policy makers). There have been 21 responses to Q1, 106 responses to Q2 (51 in English and 55 in other languages) and 8 responses to Q3.

The main points coming out from Q1 can be summed-up as follows.

Eighty-five per cent of science education projects produce and disseminate teaching and learning materials, tools or environments. Other types of outcomes that are usually developed by science education projects are guidelines of good practices, networks of people

Table 2. Projects and their contexts.

PROJECTS CONTACTED		
PROJECTS FUNDED BY THE EC (7TH FP)	PROJECTS FUNDED BY THE EACEA (LLP)	PROJECTS FUNDED BY PUBLIC (NATIONAL) ORGANISMS
CoReflect		
Engineer		
Establish	AESTIT	
Fibonacci	Compass	
Ingenious – ECB	CrossNet	
Inquire	eTwinning	Compec (Spain)
Iris	EU Train	Epse (UK)
Nanoyou	EU-HOU	EUSEA (AT)
Nanochannels	FEAST	MUSE (ES)
OSR	GIMMS	PON Scienze (IT)
Pathway	ICT for IST	Projekt X (DA)
Primas	Inspire	ROSE project (NO)
Sails	Items	Scienze Integrate (IT)
Scientix	SceTGo	SINUS (DE)
Sed	SETAC	STELLA (IT)
S-Team	Spice	STENCIL (IT)
Traces	Stencil	
Twist	UniSchoolsLab	
U4Energy		
Xplore Health		

and materials for teacher training. These types of outcomes were developed and intended to be disseminated by more than 60% of the projects listed in Table 2. On the other hand, projects' outcomes that are not so frequently disseminated correspond to theoretical or empirical research findings.

All science education projects are intended to reach teachers and professors. This is the common target audience that all science education projects share. About 75% of funded science education projects also intend to reach other target audiences such as teacher trainers, policy-makers and other project managers. Less than a third of the analysed projects intend to reach science events' organisers, science centres' managers, editorials or other society agents like parents or industries.

All three types of dissemination strategies (text-based, media-based and face-to-face) are frequently used in funded projects. However, not all specific dissemination strategies are used with the same frequency.

According to the reported results, public project documents or reports seem to be the most common text-based strategy to reach target audiences. Articles in academic journals and/or professional journals are not so widely used to disseminate project outcomes.

Concerning media-based strategies, Internet (e.g. portals, websites) is by far the most common dissemination channel to reach target audiences. In particular, projects' websites and the ones created by the ministries of education are the most common examples of Internet portals through which project outcomes are disseminated. Other dissemination channels such as mass media or social networks do not appear to be used in the analysed projects. Regarding mass media such as TV documentaries as dissemination channels, they are considered strategies that tend to have a very poor effect on disseminating project results or ideas in depth.

Two main categories were distinguished within face-to-face dissemination strategies: traditional events such as conferences or seminars, and participatory techniques such as face-to-face communities of practice or workshops. These two dissemination strategies are used in funded projects with approximately the same high frequency.

Project outcomes such as teaching and learning materials or teacher training materials are mainly disseminated combining reports, brief documents, websites or participatory techniques. Outcomes like empirical research findings, theoretical contributions or reviews are mainly disseminated using academic or professional journals, websites and face-to-face traditional events such as conferences.

As for the Q2 feedback, the main trends are described below.

Teaching and learning materials, tools or environments are the most common science education projects' outcomes that reach teachers since 86% of them recognize that this is the kind of outcome of which they have been informed from funded projects. Other types of outcomes that usually reach teachers are guidelines of good practices, and networks of people. These types of outcomes reached about 50% of the teachers who answered Q2. The types of outcomes that have lower impact among teachers (less than one third of teachers) are: reviews of already existing literature or studies, theoretical contributions and findings from empirical research studies.

Teachers usually get to know projects' outcomes by means of all three types of dissemination strategies (text-based, media-based and face-to-face) used in funded projects. However, not all specific dissemination strategies reach teachers with the same frequency. According to the reported results, public project documents or reports seem to be the most common text-based strategy by means of which projects' outcomes reach teachers. Articles in academic and/or professional journals are not so widely used by teachers to reach project outcomes.

Concerning media-based strategies, Internet (e.g. portals, websites) is by far the most common dissemination channel to reach teachers. In particular, projects' websites are the most common examples of Internet portals through which teachers get to know projects' outcomes. Other dissemination channels such as newsletters, mass media or social networks do not appear to be so frequently used by teachers to get informed of funded projects.

Finally, two main categories were distinguished within face-to-face strategies: traditional events such as conferences or seminars, and participatory techniques such as face-to-face communities of practice or workshops. These two dissemination strategies are used by teachers with approximately the same high frequency. Although, in general terms, all three types of strategies seem to be used very frequently, specific strategies are used more than others by teachers to reach certain types of project outcomes.

Concerning the Q3 results, the main points are given below.

Teaching and learning materials, tools or environments, networks of people and repositories of resources and practices are the most common science education projects' outcomes that reach policy-makers since more than 60% of them recognize that this is the kind of outcome of which they have been informed from funded projects. The types of outcomes which have lower impact among policy-makers are: reviews of already existing literature or studies, theoretical contributions, findings from empirical research studies and materials for teacher training.

Policy-makers usually get to know projects' outcomes by means of all three types of dissemination strategies (text-based, media-based and face-to-face) used in funded projects.

However, not all specific dissemination strategies reach policy-makers with the same frequency. According to the reported results, public project documents or reports and brief documents seem to be the most common text-based strategy by means of which projects' outcomes reach policy-makers. Articles in academic and/or professional journals are not used by policy-makers at all to reach project outcomes.

Concerning media-based strategies, Internet (e.g. portals, websites) is the most common dissemination channel to reach policy-makers. Other dissemination channels such as mass media or social networks do not appear to be used by policy-makers to get informed of funded projects.

Finally, traditional events such as conferences or seminars seem to be the most effective face-to-face dissemination strategy used by policy-makers.

H. Discussion events discourse analysis

Discussion events were recorded and, according to their format, researchers accessed either the audio-video version or the written one. Starting from those transcripts, researchers clustered comments and suggestions according to crucial topics (i.e. type of strategies used, dissemination strategy audience, perceived quality of dissemination activities, evaluation tools re dissemination campaigns, communication barriers etc.) as investigated through the questionnaires items. The main outcomes of discussion events concerning science events and science museums organizers can be summed-up as follows.

As to dissemination channels, most science museum and events organizers recognize that they rely on direct contact with scientists to get information, as well as for understanding how a topic is tackled. The live human network seems more appreciated than the internet social network. Conferences on science communication and education are seen as a very good access to new projects and practice.

Concerning research findings on informal science education, many science museum organisers agree that there is a need for more research on informal science education or for a common European database were all on-going and finished science education projects would have to deliver their results. This searchable database would include material for specific groups of interest, and results from research-actions experiences which do not usually get published in academic journals.

As for the involvement of stakeholders, science museum organizers also agree on the need for involving the potential users in meetings or in an advisory board from the beginning of a funded project for dissemination purposes.

About national support and initiatives, science museum organizers recognize the potential of national databases, teacher and science educator networks, and experts consulting, in order to connect people and to redirect them to appropriate sources and references.

As to reference database/portals, many science museum organisers consider that there is not one specific place on the Internet to start their research about projects' outcomes or products. One strong suggestion is the idea of building one single EU database, organised in such a way to enable teachers, communicators, trainers to find through keywords and tags straight links to projects, reports and published references resulting from all EU projects related to a certain topic. Specifically, such a unique database would be a perfect starting point for practitioners seeking resources which come from different projects focused on similar topics.

Conclusions

Our results show that a significant number of project managers (two thirds of respondents) consider that they do not receive too much information from science education projects. Similarly, about half of the teachers and policy-makers who answered the questionnaires also appraised the amount of information received as scarce or non-existent. Given this situation, it seems necessary to look for improved ways to carry out the dissemination of projects' outcomes in order to overcome the gap between different stakeholders.

Comparing projects' managers intentions with regards to dissemination and the impact of specific actions perceived by different stakeholders, some needs have been identified that should be taken into account in order to improve how dissemination is carried out. This study evidences that all science education projects are intended to reach teachers, and most of these projects also intend to reach other target audiences such as teacher trainers, policy-makers and other project managers. According to the results of this study, teachers and teacher trainers, as the main target audience, are usually contacted through multiple text-based strategies, websites and face-to-face strategies in order to make project outcomes known and understood by these audiences. In fact, they are the only target audiences that are involved in face-to-face participatory techniques, such as workshops and communities of practice, whereas other target audiences like policy-makers and other projects managers, are usually reached by a fewer number of dissemination strategies such as public reports, articles, websites and traditional events (e.g. conferences).

As evidenced in the on-line discussion events, some project managers have some reservations about using participatory techniques as dissemination strategies since they are considered very demanding and time-consuming, they require a lot of involvement of all parts, and they do not tend to have impact at a large scale. There seems to be also some pressure for scaling up innovations so that research-based practices are more widely spread among teachers. Given this appraisal, we can interpret that project managers decide to invest time and effort to use participatory techniques in case they intend to reach and have a deep impact on the main target audiences and potential users: teachers and teacher trainers.

While teachers seem to be keener to use dissemination strategies that support them in their teaching practice and that allow them to interact and network with other teachers and researchers (e.g. face-to-face strategies, social media, etc), other target audiences such as policy-makers and science museum organizers stress the need for more media-based dissemination strategies such as online portals that were considered by practitioners a reference contact point that may facilitate the search for projects' outcomes. All of them agree on the need for involving target audiences throughout the lifetime of projects as intermediate stakeholders in order to have a higher impact in practice, playing and active role in the dissemination plans and actions.

Concerning the characteristics of the dissemination strategies, our results evidence that teachers and policy-makers recognize that main dissemination strategies through which they reach projects' outcomes (i.e. project reports, websites and traditional events) usually use English as a preferential language and take a considerable amount of time. This is a contrast to what some teachers and policy-makers state when commenting on the gap

between research and practice or research and educational policy. Moreover, policy-makers recognize that they often do not have the time to pay attention to project results published in the style and media typically used by researchers. Some teachers also emphasize the need for including dissemination materials in other languages than English and the need for organizing more dissemination initiatives (e.g. conferences) at a local or regional level.

Regarding the quality of dissemination actions, we have also identified some needs that deserve our attention. Although most project managers who participated in our study recognized to feel satisfied about the dissemination plan and actions they had carried out, it is also the case that many of them claim that it is difficult to appraise the quality of dissemination actions since there is a lack of criteria to evaluate it. The most common criterion of evaluation is the number of people who are reached using any of the dissemination strategies implemented in the project. This quantitative indicator seems necessary to evaluate whether dissemination actions make project outcomes available to the target audiences. However, this criterion does not seem to evaluate dissemination actions sufficiently in depth considering that dissemination also involves making project outcomes understandable and usable in order to facilitate their use or exploitation. Other qualitative indicator used in projects refers to the target audiences' perception of the quality of the project. This criterion might allow evaluating whether target audiences consider that dissemination channels are usable and the outcomes are clear, useful and ready to be used in practice. However, this criterion seems difficult to use in order to measure the quality of a dissemination plan since it would require surveys or interviews to participants. Therefore, there seems to be a need for developing these kinds of instruments that allow appraising the quality of dissemination actions. As it has been also evidenced in this study, one of the indicators of quality that should be considered has to do with the incentives or rewarding system (e.g. equipment for the school, training, human mediation and support) provided to teachers.

In sum, these preliminary results of the DESIRE project point out some actions that might be carried out in order to improve how dissemination is usually planned and carried out. In this sense, the following phase of the DESIRE project will consist of elaborating guidelines that might contribute to improve the current situation regarding dissemination of science education projects' outcomes.

The expected outcome of the project is to deliver a toolkit, that will be ready by November 2013 and made publicly available. The toolkit will contain a set of guidelines, addressing the various stakeholder groups, on how best disseminate project outcomes to intended target audience and will describe the main results from the DESIRE research activities. Several international workshops will also be held by partners by the end of the project (November 2013) in order to present a draft version of the toolkit and gather further feedback for finalizing it. The first workshops for presenting the Toolkit were held already in May (science events organizers, Israel) and June (science museums organizers, Sweden). The next exploitation workshops will be held in August (teachers, Belgium) and September (researchers, policy makers, Turkey).

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References

- Directorate General for Education and Culture, European Commission (2010). *Developing Coherent and System-wide Induction Programmes for Beginning Teachers: a Handbook for Policy Makers*. Brussels, European Union.
- Directorate-General for Research and Innovation, European Commission (2012). *Communicating EU Research and Innovation: a Guide for Project Participants*. Luxembourg, European Union. Accessible at: http://ec.europa.eu/research/social-sciences/pdf/communicating-research_en.pdf.
- Harmsworth S. & Turpin S. (2000). *Creating an Effective Dissemination Strategy: An Expanded Interactive Workbook for Educational Development Projects*. Higher Education Funding Council for England (HEFCE).
- Joint Research Centre Institute for Prospective Technological Studies, European Commission (2010). *The Future of Learning: European Teachers' Visions*. European Communities, Luxembourg.
- Organisation for Economic Co-operation and Development (2009). *Improving School Leadership: the Toolkit*. Available at: <http://www.oecd.org/edu/school/44339174.pdf>
- Unesco (2011). *Commonwealth of Learning. Guidelines for Open Educational Resources (OER) in Higher Education*. Accessible at: <http://www.unesco.org/new/en/communication-and-information/access-to-knowledge/open-educational-resources/>

WORKSHOP PAPERS

ALTERNATIVE STAGES AND TOOLS FOR SCIENCE

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Abstract –In this communication we are showing in a qualitative way, the results of using different places outside school, to teach science and to make it closer to the society. The initiative falls in the necessity of increasing the interest of the people in general in science, as a need to get them more prepared for the current lifestyle and specially to take children attention, since they will be the future society. So that, we have done some experiments in stages such as the university, a coffee shop and even a hospital. They were chemical experiments and we have used cooking ingredients, to try to show science as a matter of course. Even social media were interested in the activities done.

Keywords: cooking ingredients, divulgation, science interest

Introduction

Scientific and technological advances in today's society are apparent in environmental, medical, economic and other issues and they are continuously increasing in complexity. However it is difficult to think that they are fully exploited, since a lack of scientific culture and knowledge by the citizens in general, has been evidenced in numerous studies. Science is not seen as an essential component of the present culture, even although it is a key element in the economical development of the countries. Therefore, there is a general need to bring science closer to society, and in this way, many initiatives may be found within the science education community (Osborne *et al.*, 2003). Among them, promoting the children's interest in science and scientific knowledge is one of the most important, in order to boost scientific careers and to contribute to a prosperous and advanced in knowledge society. According to the Nuffield Foundation inform (Osborne *et al.*, 2008), the interest that may be developed by students in science is higher below the 14 years old. However, the last PISA report in science, shows that there exists a lack of interest in young people for learning science. The origin of this situation can be found, among other causes, in the way science is taught (Rocard, *et al.*, 2007). There is a necessity for a didactic change: science traditional teaching, based on theoretical talks, abstract concepts, and numeric problems resolution versus new active methodologies, which allow students to understand scientific concepts in a meaningful context. All these considerations are taken into account by the ENCIENDE project in Spain for teaching science in school, which considers the importance of science concepts acquired at early ages (Confederación de Sociedades Científicas de España, 2011). This project regards with several proposals that could be used to promote a real modification of the teaching-learning process of science. Some of them are:

(1) the teaching of science should include activities that allow the students to enforce the theoretical concepts; (2) a connection between contents and real life; (3) the collaboration between the educative and the scientific communities, involving researchers and universities in a renewed school science-teaching pedagogy.

Chemistry related topics are in everything around us. Pinto Cañón (2003) highlights the importance of complementing this science learning with daily life examples in order to stimulate student motivation. In this sense, is important to consider de interdisciplinary character of chemistry (Jiménez Liso *et al.*, 2003). Thus, we can consider topics so different such as minerals chemical composition or chemical reactions involved in the digestion process (Castro Guío *et al.*, 2010). Getting chemistry applications to daily life closer to students through active learning methodologies, seems to help them to know and to understand issues that relate science, technology and society (Paixao, 2004).

In this sense, we present this communication to describe several initiatives that have been developed in micro-lessons format in several ambient such as primary school, researcher night and scientific breakfast at the university and visiting children at the hospital, as a way of science divulgation, according to the three proposals mentioned above. Trying to engage students and parents in scientific experiences and to promote the inquiry-based science education between primary school teachers, we have carried out several simple practices based on the use of diary life tools. The activities done agree the contents and competences established for the subject *Knowledge of the Natural Medium* in the third cycle of Primary School, according to the Decreto 82/2007 (DOE n. 50, May 3rd, 2007) where de Curriculum for the Primary Education in Extremadura (SW of Spain) is collected.

Methodology

Participants

School experience: This study has been carried out with a sample of fifty students at the sixth level of Primary School, who are distributed in two classrooms. In every room students were split and groups of 5 students were formed. All the experiences carried out were developed by every group.

Researcher night: Different aged groups of children from four to fifteen years old were hosted in a chemistry laboratory at the University of Extremadura, in Spain. Parents were integrated in this activity also. Considering the number of students, groups were heterogeneous, varying between five and ten students for each group.

Scientific breakfast: The activity was developed with five groups of ten children each. All of them belonged to the forth level of Primary School and were from the same classroom and the same school. This activity was developed in a coffee shop at the University of Extremadura campus.

Science at the hospital: The eight children participating in this activity at the hospital had different ages, from 5 to 11 years old. Their parents participated also in this activity.

Procedure

In each micro-lesson we have carried out four experiments based on chemistry concepts. All of them use household substances as chemicals, with the goal of being more familiar to

children. Previously to each experiment, students were provided with a document, where every experiment were explained, as well as the materials needed for each one and the methodology that they need to follow (Annex 1). The experiments were:

- Experiment 1. Invisible ink.
- Experiment 2. Inflating balloons without blowing.
- Experiment 3. Making a volcano.
- Experiment 4. Lava lamp.

While performing experiments, teachers role is to guide to the students not only in the experimental methodology to do the practice but also to make them think in what is happening in every experiment and find the reason to explain what is happening.

Results and discussions

Experiment 1. Invisible ink.

Before doing the experiment students showed a cautious attitude, being intrigued trying to figure out what was going to happen in the paper with the lemon juice when being heated. After doing the experiment they were too excited about the possibility of writing secret messages to their friends. The interest in the result evidenced their predisposition to understand that paper cellulose was oxidize by the flame because of the lemon juice acid catalysis.



Figure 1. Preparing invisible ink at the school.

Experiment 2. Inflating balloons without blowing.

The idea that two daily substances such as vinegar and sodium bicarbonate react between them generating an amount of carbon dioxide that is enough to inflate a balloon is so attractive to children. The idea of showing the experiment to their family and friends motivate them to learn the reaction that take place. They even may learn that the vinegar is substance called acid and the sodium bicarbonate is a substance called base, and that always an acid reacts with a base.

Experiment 3. Making a volcano.

The above reaction is showed again in a volcano simulation. The concepts showed previously were reviewed in this experiment.

Experiment 4. Lava lamp.

The importance of this experiment is in the final result, as a consequence of the immiscibility of different substances such as colored water and dishwashing gel. The bubbles dancing movements fascinated to the students, who were even more surprised when they found out the reason for the bubbles movement: carbon dioxide formed as the result of an effervescent tablet dissolution.



Figure 2. Inflating balloons with vinegar at the hospital.

The school experience meaning for children was a lesson more similar to a party, they were so excited with doing something different, so they were so interested in the activity and because of their curiosity, we were able to work the experiment explanations and the chemical related contents, so the experience turn out to be very productive (Figure 1).

Researcher night and scientific breakfast may be considered more leisure activities. The main goal was showing science as a fun activity an even somehow magical, to get the attention of the audience and specially to make them see that science is not something weird, far away from the real life but is something that we have around us continuously.

Taking science, as a game, to children suffering from any disease at the hospital, was a motivating experience to the authors of this communication. Both children and parents participating in the activity had so much expectation because it was something different to break the hospital routine and even it seemed to be something useful for the children. Moreover they found the activity enjoyable, so in some way all the participants were so grateful of having the opportunity of spending a while with experiments and science (Figure 2).

All these activities have been published by the city newspapers, so de divulgation capability of the activities carried out has been wider than what we considered when we started to plan them (Annex 2).

Conclusions

Considering the necessity of the society to get closer to science, and the importance of engaging children in scientific activities to get better formed and prepared to live in the future society, in this project we have found that it is very important that universities and researchers go out from the regular classrooms and laboratories to alternative scenarios and present science as a funny activity, which is even better if the experiments can be lived in a familiar way.

On the other hand, the use of materials, tools or reagents that we can find easily at the supermarket or at home is a fact that makes people realize that scientists and science are nothing to do with strange things, but is something that happens in the common life.

In future interventions we think that it would be interesting to focus on the search of the relationship between pure substances and daily life or biochemical mechanisms. However, the sense of these activities for us is to try to figure out how they affect to the insight that students have in chemical topics. An empirical study will be necessary for that and questionnaires will be used as tools. It will be attractive also to broaden all the interventions and analysis mentioned above to the society in general.


References

- Castro Guío D. & García Ruíz A. (2010). Aprendemos química a través del descubrimiento de los elementos químicos en el cuerpo humano en la enseñanza secundaria. *Revista Electrónica de Didácticas Específicas*, 3, 26-37.
- Confederación de sociedades científicas de España 2011. *Informe ENCIENDE situación de las ciencias en la didáctica escolar para edades tempranas en España*. Rubes editorial, Madrid.


- Jiménez Liso M.R., Sánchez Guadix M.A. & De Manuel Torres E. (2003). Química cotidiana: ¿amenizar, sorprender, introducir o educar?. Aa.Vv., *Didáctica de la Química y Vida Cotidiana*. Sección de Publicaciones de la Escuela Técnica Superior de Ingenieros Industriales. Universidad Politécnica de Madrid, pp. 15-23.
- Osborne J., Simon S. & Collins S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, 25, 1049-1079.
- Osborne J. & Dillon J. (2008). *Science education in Europe: Critical reflections*. The Nuffield Foundation, London.
- Pinto Cañón G. (2003). Didáctica de la Química y vida cotidiana. *Anales de la Real Sociedad española de Química*, 1, 44-52.
- Rocard M., Csermely P., Jorde D., Lenzen D., Walberg-Henriksson H. & Hemmo V. (2007). *Science Education Now: a renewed pedagogy for the future of Europe*. European Communities, Belgium.

ANNEX 1


1. *Invisible ink*

WHAT DO WE NEED?	HOW DO WE WORK?
<ul style="list-style-type: none"> - A piece of white paper - A swab - Lemon juice - A candle <p>CAUTION! DO THE EXPERIMENT IN THE PRESENCE OF AN ADULT!!</p>	<ul style="list-style-type: none"> - We soak the swab with the lemon juice and we write the secret message on the paper with it. - We let dry. - What should we do to reveal de message? 

2. *Inflating balloons without blowing*

WHAT DO WE NEED?	HOW DO WE WORK?
<ul style="list-style-type: none"> - An empty bottle of water - A balloon - A teaspoon - A glass - Vinegar - Sodium bicarbonate 	<ul style="list-style-type: none"> - Pour de vinegar into the bottle. (1) - Then, very carefully, we put some bicarbonate into a balloon with the teaspoon. - After that, we fit the balloon to the bottle with vinegar, trying to avoid to pour some bicarbonate into the vinegar. (2) - Finally we pour the bicarbonate in the balloon into the bottle, and then we mix everything. (3) - What does it happens? 

3. Making a volcano

WHAT DO WE NEED?	HOW DO WE WORK?
<ul style="list-style-type: none"> - An empty bottle of water - Vinegar - Dishwashing gel - Sodium bicarbonate - A spoon - Red dye 	<ul style="list-style-type: none"> - We fill two thirds of the bottle with dishwashing. - We add the dye and bicarbonate and we mix. - We add a spoon of vinegar and we wait to see what happens. <div style="text-align: center;">  </div>

4. Lava lamp

WHAT DO WE NEED?	HOW DO WE WORK?
<ul style="list-style-type: none"> - A large glass - Water - Liquid dye - Oil - Effervescent tablet - A lantern 	<ul style="list-style-type: none"> - We add water to fill one third of the glass - We add some drops of dye. - Then we add some oil to fill two thirds of the glass - After that we turn on the lantern and we put it under the glass. - Then we turn of lights. - Then we add an effervescent tablet.

ANNEX 2



María Victoria Gil, profesora de Química en la UEx, muestra una 'lámpara de lava' a los escolares del colegio Los Glacis. ■ PAKOPI

La ciencia entra en la escuela

Científicos de la UEx enseñan experimentos domésticos a niños de Primaria



EVARISTO FERNÁNDEZ DE VEGA

BADAJÓZ. ¿Cómo se fabrica la tinta invisible? ¿Puede inflarse un globo sin necesidad de soplar? ¿Cómo crear un volcán en erupción? ¿Y una lámpara de lava? A todas esas preguntas han respondido estos días las tres científicas que se han desplazado al colegio Los Glacis para llevar a cabo una actividad que trata de acercar la ciencia a los escolares de Badajoz.

La actividad ha sido promovida por la Unidad de Cultura Científica de la Universidad de Extremadura y ha contado con la colaboración de tres docentes. «La idea es transmitir que la química está en todas partes y que con herramientas muy sencillas se puede enseñar a los niños»,

explicó María José Arévalo, que trabaja en la Politécnica de Cáceres.

Uno de los experimentos que más llamó la atención fue el volcán en erupción que 'fabricó' María Victoria Gil, profesora de Química en Badajoz.

En realidad, los pequeños sólo tenían ante sus ojos una botella llena de vinagre a la que se añadió una cucharadita de bicarbonato, pero el efecto era parecido: «Eso no es lava, es espuma», dijo uno. «Pero si le echamos un poquito de pintura roja si parece lava», añadió su compañero. «Pues a mí me parece puré de verdura», señaló el tercero.

Desde la parte trasera de la clase, el tutor de este grupo de alumnos de 2º de Primaria observaba en silencio la reacción de sus alumnos. «Esta actividad tiene mucha importancia, porque la enseñanza tiene nada más que un ingrediente: la motivación. Si los niños están motivados, adquieren la capacidad de apren-

der por sí mismos», destacó Antonio Galán.

Flori Cañada, coordinadora de la actividad 'Nos divertimos con la química', se mostró encantada con la reacción de los escolares y recordó la sorpresa de un niño de cuatro años que en una de las demostraciones realizadas durante los últimos meses «se volvió loco» al ver que un globo se inflaba sin necesidad de soplar. «Tuvimos que hacérselo tres o cuatro veces y explicarle cómo se hacía. No paraba de aplaudir».

En ese caso, el milagro lo obró el bicarbonato, pero en otro de los ex-

perimentos solo fue necesaria la sal para que tres huevos introducidos en vasos de agua diferentes flotaran a niveles distintos dependiendo de la cantidad de sal añadida. «En esta ocasión hemos venido a un colegio, pero también recibimos a los alumnos en la Universidad», añadió Marta Fallola, directora del Servicio de Difusión de la Cultura Científica de la UEx.

Acercar la ciencia

Su objetivo es acercar la figura del investigador a la sociedad a través de actividades dirigidas a distintos colectivos. «Los alumnos de 6º de Primaria de los colegios que lo solicitan van a los campus de Cáceres y Badajoz para participar en un desayuno con los investigadores. También hacemos cafés científicos abiertos a la población, y organizamos actividades de todo tipo para acercar la ciencia y difundir la imagen de la Universidad», concluyó Fallola.

Vinagre, bicarbonato y sal son algunos de los ingredientes utilizados en los experimentos

Consejería de Educación y Cultura GOBIERNO DE EXTREMADURA

La Gaceta
Extremadura de la Educación

Hemeroteca

Un grupo de profesoras imparte un taller de ciencia en el Hospital Materno Infantil de Badajoz

27/03/2013

La ciencia debe estar al alcance de todos los niños. Este es el propósito de un grupo de profesoras de la UEx que han dedicado el taller 'Nos divertimos con la Química' a los niños ingresados en planta en el Hospital Materno Infantil de Badajoz

Redacción



Aprender y disfrutar van de la mano en este taller científico organizado por las docentes Florentina Cañada, Victoria Gil y María José Arévalo, pertenecientes a la Facultad de Educación, de Ciencias y la Escuela Politécnica, respectivamente.

No se trata solo de sorprender a los niños con experimentos de Química, sino también de "ofrecer esta oportunidad a los más pequeños con necesidades especiales debido a que están hospitalizados", ha apuntado María José Arévalo.

La finalidad es ayudar a los niños y a sus padres a pasar la tarde de una manera diferente, más animada y entretenida. Ilusionados, los niños pudieron comprobar que con materiales caseros es fácil y divertido jugar con la química. Así, escribieron mensajes secretos con tinta invisible, inflaron globos sin soplar, aprendieron a fabricar una lámpara de lava y descubrieron por qué un objeto se hunde o flota, entre otras muchas experiencias.

'Nos divertimos con la Química' nació de un proyecto de divulgación científica coordinado por Florentina Cañada con el propósito de difundir la Ciencia y, en especial, la química cotidiana, a los alumnos de Primaria, ya que, hasta ahora, las actividades de difusión se realizaban principalmente con

Las profesoras de la UEx durante la impartición del taller en el Hospital Materno Infantil. (UEx)

estudiantes de Secundaria.

"Existe cierto consenso entre los expertos de que la inclinación de los niños por la Ciencia u otras disciplinas se decanta en torno a la edad de 12 años", ha explicado Victoria Gil, que junto con las otras profesoras ofrecieron ese mismo taller en el CEIP 'Los Glacis'. De ahí el interés por despertar la curiosidad científica y eliminar estereotipos en edades cada vez más tempranas.

Servicio de Difusión de la Cultura Científica

Por este motivo, el Servicio de Difusión de la Cultura Científica lleva a cabo de manera regular actividades divulgativas con niños de primaria todos los meses en Badajoz y Cáceres, a través del proyecto 'Desayuna con la Ciencia', y este año volverá a coordinar en la UEx 'La Noche de los Investigadores', el 27 de septiembre.

Desde la Oficina de Responsabilidad Social Universitaria, su directora, Lola Gallardo, ha declarado que, "sin duda, la actividad de presentación de este grupo de profesoras de la UEx a los niños ingresados en el hospital reúne el conjunto de requisitos para ser considerada una acción universitaria socialmente responsable. Vemos, por tanto, cómo la Universidad trasciende más allá de sus propios límites, sale fuera de sus campus y realiza una labor social digna de mención. La Oficina de RSU de la UEx, anima a seguir realizando iniciativas de este tipo y de cualquier otro que supongan colaborar y difundir los valores sociales, sembrando ánimo y trasladando fuerza".

Esta actividad ha sido organizada en colaboración con el Servicio de Difusión de la Cultura Científica de la UEx.

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TEACHING INFORMATICS FOR FUN AND PROFIT

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Abstract – Informatics is often misrepresented as the ability to use computer applications. Instead, it is a full-fledged scientific discipline with its peculiarities and methodology. We believe that a proper introduction to the basic concepts of informatics such as information representation, algorithms, formal languages, and programming can have a positive impact on the effectiveness of secondary education, thus we started designing and implementing special teaching activities to introduce pupils to informatics through a mix of tangible and abstract object manipulations.

Introduction

Informatics has little to do with the skilled use of a bunch of specific applications: in fact, being fluent in using a given computer application is largely independent from the knowledge one may have in the discipline. In other words: to be able to read a clock one needs virtually no knowledge about the laws of pendulum.

An interesting remark about the various interpretations of the term informatics is due to Claudio Mirolo (2003), one of the promoters of the Task Force for the Research on Teaching of Informatics at the University of Udine, who identifies at least three possible acceptations, corresponding to different cultural approaches:

- *informatics as a science*, providing its own peculiar key to interpret reality and its specific approach to problem solving;
- *informatics as a technology*, concerning the characteristics, structure and working principles of the now ubiquitous hardware and software devices;
- *informatics as an instrument*, providing practical tools to manage information in many different contexts.

Informatics in Italian secondary schools

The secondary school system in Italy was reformed by several national laws in the years 2004-2010 and it is organized in two levels (Cartelli, 2002).

Lower secondary education

In the lower secondary education informatics is not a subject taught by itself, but pupils attend 6–9 hours per week of “Maths and Science” and 2 hours of “Technology” in which informatic topics should be introduced.

Upper secondary education

The upper level, generally planned on 5 years, is rather diversified and dozens of different schools exist. In the Lyceum (aimed at a general education typically refined with further tertiary studies) Informatics is planned only in a special Scientific curriculum focused on Applied Sciences. However, for all the Lyceum schools in the first two years Mathematics should include also “Elements of informatics”. Technical and professional schools provide vocational education. The technical curriculum focused on Informatics presents most of the aspects of the discipline. For the other curricula, instead, the focus is mainly on the instrumental role of informatics. Even the technological side is somewhat neglected by textbooks and teachers, although the new national recommendations are rather explicit on the importance of acquiring technological and scientific competencies.

Teacher qualification

At the lower secondary level teachers with a formal education in informatics are rare, since this is not required, and the exposure of pupils to informatics in most cases is minimal or limited to the basic use of common tools aimed at office productivity.

Teachers must hold a Master degree in order to teach in any upper secondary school. In Italy in order to obtain a permanent public job, candidates have to participate to a competitive exam. This evaluation is organized with respect to the discipline to be taught, and there exists a specific section for Informatics, open to people with a degree in Informatics, Physics, Mathematics, Information Engineering, Electronic Engineering, Telecommunication Engineering, Industrial Engineering, Aerospace Engineering, Nautical Sciences. The law has also reformed the way the teaching profession is accessed. The planned idea is to have teachers with a bachelor degree in the discipline and a two-year master in discipline teaching, “Teaching of Informatics” for our discipline. Such courses have not been activated yet, however. Currently, a transitional regime started, during which people who hold a master degree may attend a one-year qualification course, called “Tirocinio Formativo Attivo” (TFA). The first edition of this teaching qualification program started in 2012 and our team is actively involved in it.

Summing up, the new organization of secondary education has introduced several learning objectives clearly linked to the scientific and technological sides of informatics. However, the current state of the teaching is still predominantly focused on applications. This is the symptom of a general misperception: whereas everybody feels it is important to have a basic knowledge about word-processors and web browsers, an understanding of computing is often considered a special domain knowledge to be acquired only by experts of the field, since it is believed to have no immediate interest or usefulness in the real world. This opinion is supported also by many educated people, as shown by the fact that the conceptual contribution of the science of computing to other disciplines (such as cognitive science, economics, mathematics, physics, and linguistics) is seldom acknowledged. However, some peculiar aspects of computing are sufficiently basic to be taught as a fundamental formative subject. For instance, consider:

- the focus on the precise description of objects, processes, and protocols;
- the management of complexity through encapsulation and reuse;
- the synthetic power introduced by the constructs of formal languages;

- the flexible use of abstractions, that can be dynamically coerced to what is more useful in any given moment, as in the case of data used as instructions and *vice versa*.

This is just a short list: informatics has certainly more to provide to general education (Hromkovic, 2006; Barr *et al.*, 2010). However, the common misperception of informatics as a bunch of applications has negative impacts on the discipline: brilliant students tend to be attracted by other sciences because they are not familiar with the challenges of our discipline, freshmen in computing courses sometimes have distorted expectations, public funding of basic computing research is hard to raise, etc. What can be done to change this matter of fact?

Our proposal

In order to show the broader impact informatics may have on secondary education, we started designing and implementing special teaching activities to introduce pupils to selected topics: specifically, information representation and programming. We developed the following workshops.

- *Wikipasta*. On the role of formatting and on how to represent the meta-information it conveys. In this workshop pupils are posed the problem of describing the typographic aspect of a text. By playing with pieces of pasta and other small objects, they are led through a game to the discovery of mark-up languages and then introduced to a light-weight “wiki” syntax. The final activity on the computer is about editing Wikipedia-like pages.
- *Human pixels*. On the digital representation of images. After being shown a video of animations made in stadiums by coordinated soccer teams supporters (so called “human LCD”), pupils are asked to discuss how to set up a very simplified version of such animations. They eventually discover grids, sampling, resolution, compression and complete the activity by using a multi-view editor showing a picture along with different representations as a matrix of numbers.
- *Mazes*. On algorithms. In this workshop pupils are faced with the problem of guiding someone through a simple maze. Pupils first focus on the task of verbally guiding a human robot (a blindfolded mate) through a simple path. Initially they are allowed to freely interact with the robot, then they are requested to propose a very limited set of primitives and to compose them into a program to be executed by the robot, with the possibility of exploiting three basic control structures (if, repeat-until, repeat-n-times). After this, pupils are provided with a visual programming language (a simplified version of MIT Scratch) and are asked to write programs guiding a sprite through mazes of increasing complexity.

We had the opportunity to test such workshops in a lower-level (age 11-13) and in an upper-level (age 14-19) secondary school (Bellettini *et al.*, 2012, 2013). As a result, we could refine the design of these activities, and prepared a set of two-hours workshops which we proposed to classes of 20-25 pupils. A total of 26 classes attended each one of the workshops. Our intention was twofold:

1. propose a methodological approach to informatics teachers, and
2. present some core aspects of informatics to both pupils and teachers.

From a broader perspective, we aim at conveying a view of informatics as a scientific discipline, as opposed to the current perception of this field. We also paid attention in designing workshops requiring resources that are commonly available or easy to prepare (pasta, colored sheets,...), and the software used is downloadable for free and runs on standard PCs.

References

- Barr J., Cooper S., Goldweber M. & Walker H.M. (2010). What everyone needs to know about computation. In: Lewandowski G., Wolfman S.A., Cortina T.J. & Walker E.L. (Eds). *Proceedings of the 41st ACM technical symposium on Computer science education, SIGCSE 2010*, Milwaukee, USA. pp. 127-128.
- Belletini C., Lonati V., Malchiodi D., Monga M., Morpurgo A. & Torelli M. (2012). Exploring the processing of formatted texts by a kynesthetic approach. In *Proceedings of the 7th workshop in primary and secondary computing education – WiPSCE '12*, ACM. New York, NY, USA. pp. 143-144.
- Belletini, C., Lonati, V., Malchiodi, D., Monga, M., Morpurgo, A. & Torelli, M. (2013). What you see is what you have in mind: constructing mental models for formatted text processing. In Diethelm I., Arndt J., Dünnebier M. & Syrbe J. (Eds). *Informatics in Schools: Local Proceedings of the 6th International Conference ISSEP 2013 – Selected Papers (Universität Potsdam, Germany)* 6 (pp. 139-147). *Commentarii informaticae didacticae*, Universitätsverlag Postdam.
- Cartelli A. (2002). Computer science education in Italy: a survey. *SIGCSE Bulletin*, 34 (4), 36-39.
- Hromkovic, J. (2006). Contributing to general education by teaching informatics. In *Informatics Education – The Bridge between Using and Understanding Computers. Proceedings of ISSEP 2006*, LNCS 4226 (pp. 25-37) Springer, Vilnius, Lithuania.

Web references

- Mirolò C. (2003). Quale informatica nella scuola?
<http://nid.dimi.uniud.it/pages/materials/discussion/educazione.pdf>. In Italian; last access on July 2013.

INQUIRY BASED SCIENCE EDUCATION IN VIRTUAL WORLD

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Abstract – The project starts from the methodology of the Inquiry-Based Science Education applied in 3D virtual environments and in a serious game. Learners in the island following questions involve scientific skills. The project wants improve motivation in students for a scientific virtual path with an immersive approach.

Keywords: Virtual Worlds, IBSE, serious game

Introduction

The 3D virtual worlds (multi-user) provide educational opportunities to learn in a socially-interactive learning community. Many authors claim that “immersive” methodologies produce an improvement in cognitive and perceptual dynamics (Aldrich, 2005). In recent years the development of technologies and the educational scenario has prompted a change in the design of environments in which the experience training takes place.

Methodology

The project starts from the methodology of the Inquiry-Based Science Education (IBSE) applied in 3D virtual environments using a serious game. An island created in 3D, called Science Island, where, through a role play, learners cross the various steps, 10 activities based on inquiry (Scapellato, 2012). In every activity there are 5 phases: engage – explore – explain – elaborate – evaluate. The theme chosen for the task is “Water and Life”, from point of view geological, chemical, physical and biological. The level of inquiry chosen for the path (Scapellato, 2011) is structured inquiry, where teachers shows which experiments students must do to search an answer to the question in every step of path. The island, a Opensim (http://opensimulator.org/wiki/Main_Page) of INDIRE (Italian National Agency for the Development of Education), this is a project on teaching in virtual worlds called Edmondo (<http://www.secondlearning.it/>). This Science Island has a visible structure in figures 1 and 2.

Each step begins with a question before moving on to experimental activities with specific goals to achieve competence to return then to virtual where, if the target has been reached student can switch to the next step. The opening narrative is: an alien arrives from a planet without water on our planet to study this unknown substance in order to be able to then use to save his planet from destruction. Learners in the island following questions,

steps and experiments have improve scientific skills and improve motivation in scientific study. The target was students between 13 and 16 years. The project was applied in two classes with 25 students in a high school (ISIS Pitagora Naples), during 3 months using the chemistry laboratory. Every student had an avatar. Before the project we had given a pre-test to every student on the topic “water and life”. At end we had given a final test on this same topic to check learning using an immersive path. Another class was control group.



Figure 1. Island map.



Figure 2. Start point in serious game.

Results and discussion

The aim of this project was to understand the influence on learning of the immersive education. The result of the pre-test showed a low knowledge on water and its relations with life, at the end of the project the post-test showed that knowledge was improved together with the scientific skill. During the project we had given also a satisfaction's questionnaire; in this questionnaire students showed that they preferred an immersive education at the traditional education. These results are only the first step of project, in future other topics will be implemented using immersive education in 3d virtual worlds. In future we want to understand if every scientific topic can be learned using virtual worlds or only some topics.

Conclusions

This project gives an example of effectiveness of immersive education using virtual worlds and serious games can be a new way in scientific education. In future new experiences will be on this e-learning and immersive paths testing scientific skills of learners.

References

- Aldrich C. (2005). *Learning by doing: A comprehensive guide to simulations, computer games, and pedagogy in e-learning and other educational experiences*. Pfeiffer San Francisco, CA.
- Scapellato B. (2012). Investigare il ciclo dell'acqua. *Rivista Linx Magazine*, 12, 46-50.
- Scapellato B. (2011). I Livelli di Inquiry. In blog L'ingrediente segreto Istituto dell'Inquiry. Available at: <http://www.exploratorium.edu/ifi/>. Accessed: November 2, 2011.
- European Commission (2007). *Science Education NOW: A renewed Pedagogy for the Future of Europe*. Office for Official Publications of the European Communities, Luxembourg.
- Osborne J. & Dillon J. 2008. *Science Education in Europe: Critical Reflections*. The Nuffield Foundation, London.

Web references

- Rapporto Rocard-ADI http://ospitiweb.indire.it/adi/RRocard/rr7_frame.htm Rapporto Rocard Available at: http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf
- Island movie: <http://www.youtube.com/watch?v=-cF5une6MJw&feature=youtu.be>

EVOLUTION OF ALTERNATIVE CONCEPTIONS ON PURE SUBSTANCES AND MIXTURES OF PRIMARY EDUCATION STUDENTS'

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Abstract – Alternative conceptions in science, resulting from the students attempts to understand their previous experiences, are very important to be considered in education in order to promote the significant learning. Students get to Primary School with a series of alternative ideas that need to be detected as a previous step to get changed by the right conceptions. This work aims to ascertain the previous ideas of students in the third cycle of Primary Education on material systems and on the differences between pure substances and mixtures. In our study a sample of twenty one students from third cycle of Primary Education was chosen. A questionnaire consisting of three open and closed items was used as instrument. The answers were analysed and used to design a didactical instruction. Further an evaluation has shown the usefulness of the proceeding.

Keywords: Alternative conceptions, conceptual change, material systems, Primary Education

Introduction

One of the most important concepts of chemistry is the concept of substance, because it allows recognizing and identifying the field of study of chemistry. Moreover, this concept is very important in daily life because people can identify dangerous substances and avoid interaction with them (Guzmán Vázquez *et al.*, 2005). Although, despite its importance, the concept of substance is used as a synonym for material, product, object, etc.

The recognition of the diversity of matter is a fundamental goal of teaching chemistry (Martínez Losada *et al.*, 2009). Material systems are introduced firstly in Primary Education through the Environmental Knowledge subject and they are studied more in-depth in the secondary education.

In the Spanish Autonomous Community of Extremadura, the main regulation that establishes the curriculum for Primary School (Decreto 82/2007 April, 24th; DOE n. 50 May, 3rd 2007) establishes contents in relation with physical phenomena, the substances, state of the matter, physical and chemical changes for the three cycles of Primary Education. Those contents are integrated in *Knowledge area of natural environment, social and cultural*, exactly in the seventh block, *matter and energy*.

Alternative conceptions and conceptual change

Students have ideas on many scientific contents, which are often misleading and confusing. Those ideas are called *alternative conceptions* and are very important in the education process. They may be defined as individual constructions or mental representations of the world that allow to understand the environment and to act according to them.

Constructivist teaching-learning model takes special interest in knowing students' alternative conceptions. These ideas lead to conceptual mistakes and they are an obstacle in learning scientifically correct concepts. Therefore alternative conceptions must be considered by the teacher during the educational process to ease the rebuilding of the knowledge in a significant way. Connecting both, previous and new conceptions, makes the new knowledge acquire a real meaning (Furió *et al.*, 2006).

The conceptual change is essentially the modification of student's alternative conceptions and their substitution by others accepted by the scientific community with the goal of the students learning the right concepts (Campanario, 2002). Learning scientific concepts do not consists only in replacing any idea by other scientifically accepted, but in making connections between spontaneous student theories and scientific theories. Students must get to understand the superiority of accepted theories being necessary for that facing them to conflictive situations that are not able to be solved by using their own theories. This is imperative for getting a conceptual change (Pozo, 1989). The new information must be understandable by the students, consistent with other theories and with their own experiences. It must solve problems that the previous idea is not able to, especially daily problems.

Alternative conceptions about material systems

Not many studies have been carried out in relation to the alternative conceptions about pure substances and mixtures. Considering the Primary School level the number is even more limited. This is probably due, according to Rubio Cascales (2010), to the opinion of authors thinking that these contents are scientific complex and with a sort of abstraction and should be moved on to the Secondary School level. Regarding to the Primary School level, it is important to highlight the research done by Martínez Losada *et al.* (2009). This group studied alternative conceptions about pure substances and mixtures at different levels. They noted student challenge is in differentiating pure substances of mixtures, especially homogeneous mixtures. Pupils also think that both, compounds and mixtures, are formed of several pure substances. In the same way, Martín del Pozo and Galán Martín (2012), checking that the most of students (from all Primary Education levels) identified to granite stone as pure substance, indifferently that they can see that is composed of different minerals, they concluded that natural origin prevails about perception. Also, in Martín del Pozo and Galán Martín study, students match mixture with processed material, classifying the iron and copper as mixture.

Furió-Mas and Domínguez Sales (2007) have observed similar alternative conceptions with regard to pure substance and mixture, in a research that has been done with Secondary School students. An explanation to this fact given by Ben-Zvi *et al.* (1986), that students think in a compound as a random mixture of atoms because they do not have a right microscopic representation of the substance structure concept.

This work aims to ascertain the previous ideas of students in the third cycle of Primary

Education on material systems and on the differences between pure substances and mixtures. To get this goal, we have utilized a questionnaire. Then, we have tried the students to overcome their alternative conceptions by an instruction and a practical lesson and finally we have evaluated the effectiveness of the whole project.

Methodology

This study follows a descriptive and interpretative methodology with the aim of describing, explaining and understanding mental representations that the third cycle of Primary School students have in relation to the different material systems. A Public School of Primary Education in Badajoz (Spain) has been chosen to study alternative conceptions of students. The selected sample is formed by twenty one students of the fifth course of primary education.

A questionnaire consisting of three questions, open and closed, was used as instrument. The selected questions were adapted from different studies in relation with the topic (Martínez Losada *et al.*, 2009 and Martín del Pozo and Galán Martín, 2012), (Annex 1). The questionnaire was completed by students in the class. Questionnaire was completed by students twice; before and after instruction. The instruction consisted in two steps: 1) interactive presentation; 2) chemistry workshop.

The experience was developed along four weeks. In the first two weeks, pre-test was accomplished, and after analysed, alternative conceptions of students were detected. Then, the instruction was planned, on basis to the obtained results. In the third week, the instruction was carried out into a session class of 90 minutes (30 min interactive presentation and 60 minutes chemistry workshop). In the last week, post-test was implemented, analysed and compared with the pre-test results. In figure 1 is included the scheme followed in this work.

Results and discussion

Followed we proceed to the presentation and discussion of the results obtained in the three steps of the study. The results and discussion are presented for each question, obtained data are showed and compared before (pre-test) and after (post-test) the didactical intervention.

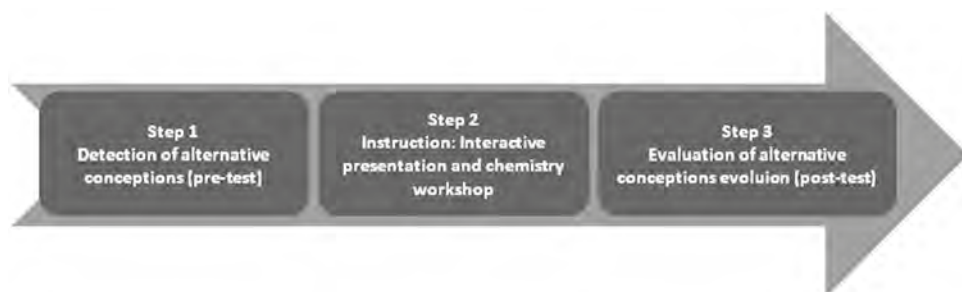


Figure 1. Steps of the study.

Question 1

In the first question, students were asked about a mixture of water and oil, if it was a homogeneous or heterogeneous mixture and also to justify the response.

In pre-test, 71% of the students marked homogeneous option, in this case the wrong option (Figure 2). Most of student did not know to classify properly the mixture oil/water. But, when the justifications were analysed 24% used a correct definition: *mixture where the components are distinguished*. Students know that substances remain separate but they do not match with correct criterion. After the didactical instruction, 95% students classify mixture as heterogeneous (Figure 2). Respect to classification criteria, 40% of student used phrases related to *“mixture where the components are distinguished”*. Nevertheless, some of the students (28%) justified in base to the different density of the mixture components and although is true, the answer was considered wrong. Moreover, analyzing the answers, – *because no mixing to be oil denser* – it can deduce that students wrong density and viscosity. The results are similar to the obtained by Cañada Cañada *et al.* (2013).

In this case, we can conclude that didactical instruction was positive and the alternative conception evolved toward the scientifically correct concept.

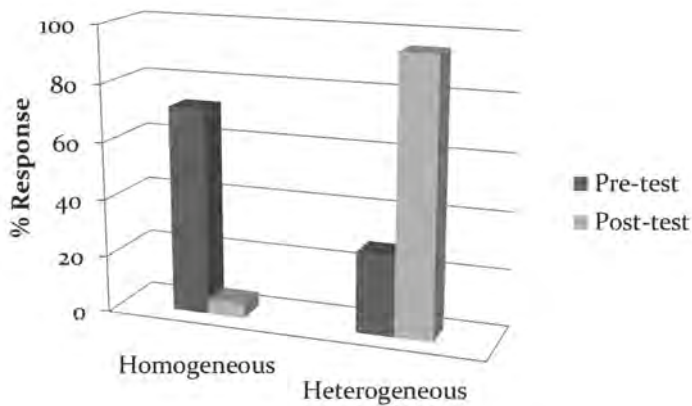


Figure 2. Evolution question 1, homogeneous/heterogeneous.

Question 2

In the second question, students had to justify if milk is a pure substance or a homogeneous mixture. Most of the students (86%) choose wrongly pure substance (Figure 3). Around 43% of students identified milk as a pure substance, claiming to its natural origin. Examples of responses: *because milk comes from cow*; *because a mixture is to mix something and the milk is natural*. These students match “natural” with “pure”. Moreover, in the communication media, milk is advertised as “pure milk from cow” and this confuses to the people. On the other hand, their visual experience makes the milk be classified as a pure substance because they cannot distinguish its components, only see a white liquid. The results are similar to the obtained by Martínez Losada *et al.* (2009). Both studies highlight the difficulty for students to differentiate a pure substance and a homogeneous mixture.

After instruction, 65% of student classified properly the product (Figure 3). However, the most important advance was in the justifications given by students because 61% of students justified the question in a correct way – *milk is a mixture because is formed by several components*.

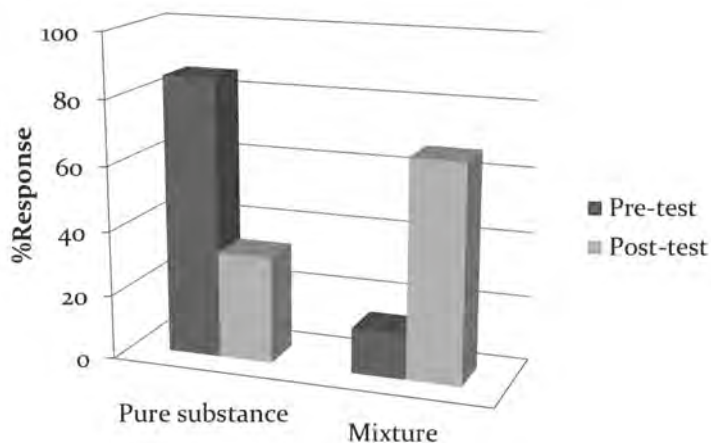


Figure 3. Evolution question 2, pure substance/mixture.

Question 3

In the third question, students had to classify twelve products (yoghurt, salt, coke, diamante, water, copper, ice, iron, oil, granite stone, silver, and sand) as a pure substance or a mixture.

In figure 4 are shown the percentage of election for each product before and after the didactical instruction. We can see, students have problem to classify iron, copper and silver as pure substances, it could be due to those are materials that they normally used in processed way. On the other hand, students present difficulties to choose properly mixtures

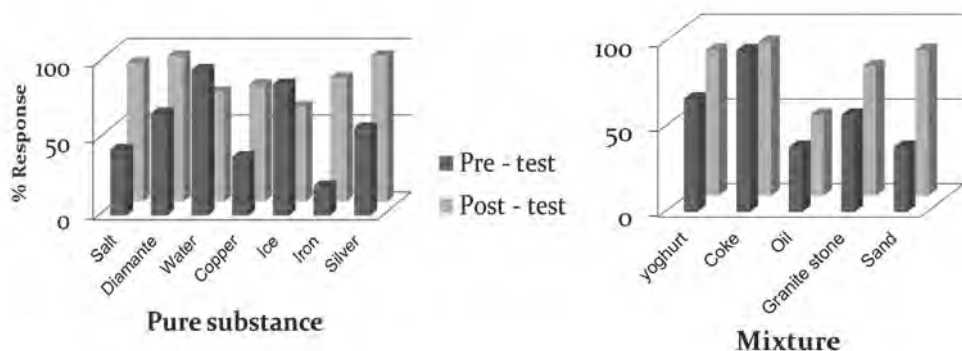


Figure 4. Evolution question 3, classification pure substance/mixture.

such as oil, granite stone and sand. That is similar to data obtained by Martín del Pozo and Galán Martín (2012). We consider that it could be because their natural origins.

Respect to classification criteria, the origin (natural or manufactured) remain versus composition. Students used justifications such as “*They are processed substances*” or “*It is artificial*” to justify the election of iron, copper and silver like mixtures.

After instruction, percentages of right choice increase in almost all cases, except water and ice that suffer a weak regression. With regard to justifications, most of students used correct criteria.

Conclusions

The presence of alternative conceptions in students of third cycle of Primary Education has been detected. They do not difference between a pure substance and a mixture, especially if the mixture is a natural product like cow milk. Hence, students have a restricted conception of mixtures that is specially focused on what they perceive and it excludes products that are naturally mixed, including heterogeneous samples like granite stone or sand. Also, students have difficulties respect to the distinction between homogeneous and heterogeneous mixtures. Therefore from this study we highlight that the concepts of pure substance and mixture are difficult to assimilate by the students.

Overcoming the above mentioned previous ideas is possible after an instruction followed of a practical lesson. Always guided by teachers, makes them contrast their previous ideas with the scientifically correct. Thus they realize that they need different or additional conceptions to explain and classify the matter composition.

It would be desirable to change students’ alternative conceptions into right scientific conceptions. It is important to note that this change must be addressed in Primary Education because these ideas persist and are shaped as mental structures that impede the science learning.

Acknowledgements

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References

- Ben-Zvi R., Eylon B.S. & Silberstein J. (1986). Is an atom of copper malleable?. *Journal of Chemical Education*, 63, 64-66.
- Campanario M. 2002. *La enseñanza de las ciencias en preguntas y respuestas*. <http://webdelprofesor.ula.ve/humanidades/marygri/documents/general/EnsenanzaCiencias.pdf>
- Cañada Cañada F., Melo Niño L.V. & Álvarez Torres R. (2013). What Students of primary know about material systems and chemical and physical changes? *Campo Abierto* (In press).

- Furió-Mas C. & Domínguez-Sales M.C. (2007). Problemas históricos y dificultades de los estudiantes en la conceptualización de sustancia y compuesto químico. *Enseñanza de las Ciencias* 25, 241–258.
- Furió C., Solbes J. & Carrascosa J. (2006). Las ideas alternativas sobre conceptos científicos: Tres décadas de investigación. *Alambique* 48, 64-77.
- Guzmán Vázquez C., Méndez Vargas N., Romero Domínguez M., Sosa Fernández P., Trejo L.M. (2005). Estrategias para introducir el concepto de sustancia y para distinguir cambio químico de cambio físico en alumnos de nivel bachillerato. *Enseñanza de las Ciencias*, Número extra. VII Congreso.
- Martín del Pozo R. & Galán Martín P. (2012). Los criterios de clasificación de la materia inerte en la Educación Primaria: concepciones de los alumnos y niveles de competencia. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias* 9, 213-230.
- Martínez Losada C., García Barros S. & Rivadulla López J.C. (2009). What students of primary and secondary know about material systems? How to treat it in textbooks? *Revista Electrónica de Enseñanza de las Ciencias*, 8, 137-155.
- Pozo J.I. (1989). *Teorías cognitivas del aprendizaje. Colección Psicología Manuales*. Marata, Madrid.
- Rubio Cascales J. (2010). *Que sabe el alumnado que acaba la educación primaria sobre las mezclas de sustancias*. XXIV Encuentro de didáctica de las ciencias experimentales. Jaén.

Annex 1 (Questionnaire)

1. Mixing water and oil, the result is a mixture:

Homogeneous

Heterogeneous

Why?

2. Milk is:

A pure substance

A mixture

Why?

3. Classify these products as “pure substance” or “mixture”: yoghurt, salt, coke, diamante, water, copper, ice, iron, oil, granite stone, silver, and sand.
Justify your election.

HELPING ITALIAN SCIENCE TEACHERS TO MAKE EARTH AND CLIMATE ACTIVE LESSONS. RESULTS OF 3 YEARS SUPPORT WITH THE ICLEEN PROJECT

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Abstract – It has been demonstrated that in Italy Earth and Climate System Sciences Education (ESS) is one of the scientific disciplines where science teachers show a greatest need in terms of professional support. Among the causes that have been reported we should mention: the predominance of science teachers with a degree in biological disciplines rather than geo-logical or physical topics, and the high interdisciplinary of certain topics, in particular those related to the climate system. Furthermore, it was found that ESS topics are predominant in the science curricula of those grades in which have been reported the major students dropout rates during the whole Italian school cycle.

In this context, in 2010, the MUSE, the Museum of Science of Trento (Italy), created a web-based service named I-Cleen (Inquiring on Climate and Energy www.icleen.muse.it). This is a tool aimed at promoting the collaboration among science teachers in order to share resources and enhance the professional collaboration by means of participatory methods and models belonging to the world of open source and open content. The main instrument of the I-CLEEN project is an online repository (with metadata compliant with the DCMI and LOM international standards) of teaching resources focused on Earth and Climate Sciences all published under the Creative Commons license Attribution 3.0 and therefore, belonging to the model of OER (Open Educational Resources). The service has been designed, developed and managed by a team consisting of very experiencing science teachers and scientists from the Museum and other partners research institutions. The editorial work is carried out online utilizing a specific platform made with LifeRay, a CMS (Content Management System) software that is open source and manageable in a single Java-frameworked environment using the dbase, the website, the editorial process and several web 2.0 services. The project has been subjected to two distinct testing activities in collaboration with the University of Trento dealing with the effectiveness of the service as well as the usability of the graphic user interface (GUI). The present work aims to illustrate the essential features of the service I-cleen and the results achieved during the last three years of operation. It will be display and interpret for the first time data with web traffic, and other data from downloading and publishing documents of the teaching resources and the main outcomes of the above mentioned tests. The purpose of this contribution is to highlight strengths and weaknesses of this experience and potentially able to provide valuable information on the role of today's web based services and online communities to help support teachers in earth and climate sciences subjects.

EMOTIONAL INTELLIGENCE AND SUCCESS IN MATHEMATICS: AN EMPIRICAL STUDY

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Abstract – Introduction. In the 21st century promotion of scientific talents is challenging (Brody, 2006; Chan *et al.*, 2010; Maree, Elias, & Bar-On, 2009) both for individual and societal development (Heller, 2005; Subotnik and Rickoff, 2010). Research on the emotional intelligence construct is a promising topic of recent interest relative to scholastic success (Di Fabio and Palazzeschi, 2009; Hannula, 2006; O'Connor and Little, 2003; Parker *et al.*, 2004; Parker, Summerfeldt, Hogan, and Majeski, 2002; Petrides, Frederickson, and Furnham, 2004; Van der Zee, Thijs, and Schackel, 2002). The aim of the present study was to take a more in-depth look at the role of emotional intelligence (both ability-based and self-reported) in scholastic success in mathematics. In particular, the study explored the presence of significant differences in emotional intelligence between two different groups of students: a group composed of gifted students in math (Group 1) and another group composed of students with average-achieving and low-achieving in math (Group 2). Methods. Three hundred ninety-two Italian students, attending the last two years of a school system in Tuscany, were divided in two groups on the basis of marks in mathematics: Group 1 ($n = 77$), Group 2 ($n = 315$). The Italian version of the *Bar-On Emotional Quotient Inventory: short* (Bar-On EQ-i:S, Bar-On, 2002) and the Italian version of the *Mayer-Salovey-Caruso Emotional Intelligence Test* (MSCEIT, Mayer *et al.*, 2002) were administered to both Group 1 and Group 2. Descriptive statistics and ANOVA one way were performed. Results. Regarding Bar-On EQ-i:S significant differences emerged between Group 1 and Group 2: gifted students resulted higher than Group 2 on intrapersonal dimension, stress management dimension, adaptability dimension and emotional intelligence total score. Concerning MSCEIT significant differences emerged between Group 1 and Group 2: gifted students resulted higher than Group 2 on facilitating thoughts, strategic emotional intelligence and emotional intelligence total score. Conclusions. The results of the present study offered an in-depth look at the relationship between the emotional intelligence construct and success in mathematics offering future research and intervention perspectives (Bar-On, 2002; Di Fabio and Kenny, 2011; Mayer *et al.*, 2002).

References

- Bar-On R. (2002). *Bar-On Emotional Quotient Inventory: Short Technical Manual*. Multi-Health Systems, Toronto, ON.
- Brody L. (2006). *Measuring the effectiveness of STEM talent initiatives for middle and high school students*. In September meeting of the National Academies Center for Education.
- Chan Y.Y., Hui D., Dickinson A.R., Chu D., Cheng D.W., Cheung E. & Luk K.M. (2010). Engineering outreach: A successful initiative with gifted students in science and technology in Hong Kong. *Education, IEEE Transactions on*, 53 (1), 158-171.
- Di Fabio A. & Kenny M.E. (2011). Promoting emotional intelligence and career decision making among Italian high school students. *Journal of Career Assessment*, 19, 21-34.

- Di Fabio A. & Palazzeschi L. (2009). An in-depth look at scholastic success: Fluid intelligence, personality traits or emotional intelligence? *Personality and Individual Differences*, 46, 581-585.
- Hannula M.S. (2006). Affect in mathematical thinking and learning. *New mathematics education research and practice*, 209-232.
- Maree J.G., Elias M.E. & Bar-On R. (2009). Emotional intelligence, giftedness, creativity and talent. In Kerr, B. (Ed.), *Encyclopaedia of Giftedness, Creativity, and Talent*. (pp. 320-322). Sage Publications, New York.
- Mayer J.D., Salovey P. & Caruso D.R. (2002). *Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT): User's manual*. Multi-Health Systems, Toronto, Canada.
- O'Connor R.M. Jr. & Little I.S. (2003). Revisiting the predictive validity of emotional intelligence: Self-report versus ability-based measures. *Personality and Individual Differences*, 35, 1893-1902.
- Parker J.D.A., Creque R.E, Barnhart D.L., Harris J.I., Majeski S., Wood L.M. *et al.* (2004). Academic achievement in high school: Does emotional intelligence the matter? *Personality and Individual Differences* 37: 1321-1330.
- Parker J.D.A., Summerfeldt L.J, Hogan M.J., Majeski S. 2002. Emotional intelligence and academic success: Examining the transition from high school to university. *Personality and Individual Differences*, 36, 163-172.
- Petride K.V., Frederickson N. & Furnham A. (2004). The role of trait emotional intelligence in academic performance and deviant behavior at school. *Personality and individual differences*, 36 (2), 277-293.
- Van der Zee K., Thijs M. & Schakel L. (2002). The relationship of emotional intelligence with academic intelligence and the Big Five. *European Journal of Personality*, 16, 103-125.

DECISIONAL STYLES AND SUCCESS IN MATHEMATICS IN HIGH SCHOOL STUDENTS

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Abstract – Introduction. A topic of interest relative to scholastic success is research on decisional styles (Galotti *et al.*, 2006; Di Fabio and Palazzeschi, in press). The aim of the present study was to take a more in-depth look at the role of decisional styles in scholastic success in mathematics. In particular the study explored the presence of significant differences on decisional styles among students that differ in mathematics achievement. Methods. Two hundred seventy seven Italian high school students attending the last two years of a school system in Tuscany was divided in three groups on the basis of marks in math: Group 1 (high-achieving students), Group 2 (average-achieving students), Group 3 (low-achieving students). Decisional styles were evaluated through the Italian version by Di Fabio (2007) of the *General Decision-Making Style Inventory* (GDMS, Scott and Bruce, 1995). This instrument measures five different decision-making styles: rational (making decisions using rationality), intuitive (making decisions based on feelings and emotions), dependent (making decisions by means of other's opinion and expectations), avoidant (the tendency to avoid or postpone decision making) and spontaneous (characterized by a sense of immediacy and a desire to complete the process quickly). Descriptive statistics and ANOVA one way were performed. Results. Results obtained by ANOVA one-way revealed significant differences in rational, intuitive, avoidant and spontaneous styles between the three groups of students. High-achieving students seem to be characterized by a higher level of rational style and a lower level of intuitive, avoidant and spontaneous styles than the other two groups of students (average-achieving students and low-achieving students). Conclusions. The results provide an in-depth look at the relationship between decisional styles and scholastic success in mathematics offering future research and intervention perspectives.

References

- Di Fabio A. (2007). General Decision Making Style (GDMS): Un primo contributo alla validazione italiana [General Decision Making Style (GDMS): A first contribution to Italian validation]. *GIPO, Giornale Italiano di Psicologia dell'Orientamento*, 8 (3), 17-25.
- Di Fabio A., Palazzeschi L. (in press). Decisional styles: New perspectives for scholastic success, [Stili decisionali: Nuove prospettive per il successo scolastico]. *Counseling, Giornale Italiano di Ricerca e Applicazioni*.
- Galotti K.M., Ciner E., Altenbaumer H.E., Geerts H.J., Rupp Al. & Woulfe J. (2006). Decision-making styles in a real-life decision: Choosing a college major. *Personality and Individual Differences*, 41, 629-639.

Scott S.G. & Bruce R.A. (1995). Decision-making style: the development and assessment of a new measure. *Educational and Psychological Measurement*, 55 (5), 818-831.

SOME EXPERIENCES ON UNIVERSITY INNOVATIVE EDUCATION

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Abstract – Innovation in Superior Education is not easy. It isn't so in a country which has a traditional scheme like Spain, and it isn't so either because it involves adapting to new concepts in education and the use of new technologies, which is, in many cases, difficult to assume. The Complutense University is aware of that, and has adopted a series of ways to be able to take a step forward in this process.

The subject *Anatomy of Exotic Animals* was implemented in the Veterinary School of the *University Complutense* in 1999, for the first time in a Veterinary School in Spain. By that time, concerns about the Principles of the Bologna Treaty and about innovation in Veterinary Education started in our University. The “Anatomy of Exotic Animals”, as well as other disciplines, was used as a tool to train teachers and students for the new time to come (those so-called *Pilot Subjects*). We all got used to substitute lectures by seminars or conferences by discussions in small groups. Students changed their role by organizing every session under the supervision of a lecturer, who starting to be “tutor”, instead of a “traditional professor”. In other words, little by little, we are changing from a teacher-centred education to a student-centred education.

In addition, the so-called “Projects on Innovative Education” are complementary tools to promote the implementation of new teaching practices in superior education. Our group has a wide experience on these projects, most of the times using Anatomy as a basis, and always with a transversal point of view. At the beginning, our main goal was to facilitate the study of exotic animals, which are increasingly important in veterinary medicine. The first step in this direction was to include a professor from the Faculty of Biological Sciences, to expand our application to different subjects included in this degree. For the first time, we started to have a more applied (less academic and more professional) approach. Anatomy evolved from being a traditional subject, too theoretical and sometimes even tedious, towards a practical and directly applicable matter in the daily activities of a veterinarian or a biologist. Thus, we began to abandon the idea of “knowledge for knowledge”, to give this knowledge a more practical sense.

Another step was to Anatomy as the basis for other applied sciences as Radiology, Pathology, Surgery or Internal Medicine. This “transversal” point of view as is essential to achieve our goals as it gives the knowledge of a basic science a more practical sense.

Keywords: Bologna Declaration, educative innovation, European Espace of Higher Education (EHEA), self-learning, student, teacher, traditional education.

Introduction

Up to date, the method used by the Spanish University has been quite traditional, and has been subject to very little innovation. The Complutense University of Madrid (UCM), as one of the oldest in Europe, is not an exception. In most cases, we are “anchored” to

a system in which the student is a subject rather passive, and the teacher has an important role. To get out of this inertia is not easy; sometimes, it is complicated to combine the self-learning with a traditional method. This work is based on the experiences our group has had concerning innovation in University education. We will start with the “Anatomy of Exotic Animals”, which was included, from 2003-2004 to 2008-2009, within the so-called Pilot Courses or Pilot Subjects, implemented by the Universidad Complutense de Madrid (UCM), to adapt the university teaching to the European Espace of Higher Education (EHEA) (1 and 2).

We will discuss how that can be passed from the board, the screen or the stylus, to the computer at home or in the library; the use of books or notes, to the use of Internet; from traditional lectures to networks of discussion. This process has been a little easier by the implementation of the so-called “Innovative Education Projects”, which are useful tools to support this process, and to produce teaching material for both students and professionals, as we shall see forward. Altogether, our group has participated in fourteen, with interesting results.

Material and Methods

Pilot Groups

The Anatomy of the Exotic Animals is an optional subject, with an average enrollment of 80-100 students per year. When we started with the experience of “Pilot Subjects”, in the academic year 2003-2004, the first question was whether to adapt all the students to the methodology of the EHEA, or if it should be better to do it with a small group. We chose the first alternative, because of two reasons: first, the subject has three clearly differentiated parts in small mammals, birds and reptiles, and then, we wanted to give all students the opportunity to compare two teaching methods that have little to do with each other.

We divided the students into three groups, known as A, B and C. Reasons of friendship or other affinities were avoided. It has to be taken into consideration that one of the skills to acquire with this new method is the ability to work together as “teamwork”. In the first part of the course, group A (birds) was acting as “pilot group”, while B and C received a traditional teaching. Then, group B (small mammals) acted as “pilot group”, while A and C received a traditional teaching, and finally, group C (reptiles) was the “pilot group”, while A and B received a traditional teaching. We did not do any difference between groups in the practical classes, because all practicals have a very applied approach, in which a personal work is essential.

The balance of this first experience showed us that to reach the level of teacher-student interaction we wanted, it was better to work with a small group. For this reason, we decided to reduce the number of students participating in the “pilot group” to 40, making it a fully voluntary basis. The remainder was teaching “traditional”, with master classes. The advantage was the possibility of a constant comparison between both methods within the same academic year.

The main question is: what is “pilot group”? (3). The answer is, basically, as follows: the course is divided into “sessions”, focused on different contents. These contents are known in advance by the students, who have to organize every session of discussion. We have a first meeting, in which we explain the reason for these changes, the methodology of work,

the objectives pursued, the tools they can use, and the academic and disciplinary competences to be acquired.

Students seek information on the Internet, download data and material that the professor put in the so-called “UCM virtual classroom” (4), consult books (5 and 6), organize oral presentations, etc. The discussion sessions are conducted in the presence of the teacher, who constantly interacts with students. They even resolved issues that have not been sufficiently clear. The result of each of these sessions is cumulative, in a clear process of “continuous assessment” or “continuous evaluation”.

This point, student’s marks, is another key issue. Our original intention was to put an individual grade to each student, because we thought it might be more stimulating. Thus, a clear distinction was made between those who had worked harder and better. With time, we changed to consider each group as a whole, as we observed that the degree of knowledge, participation, interest, etc., was very similar, and we wanted to avoid the feeling of being “under review or examination”. Our desire was to promote student’s activity, leaving behind the traditional concern over making a mistake in answering a particular question.

Since the academic year 2008-2009 we have decided to add a little test at the end of the sessions. This is just to get a better idea of the knowledge attained by every student. Therefore, at the end of each session, there are two grades: one that could be called “group grade”, which assesses contents and the way the collective work is presented, quality of the images, etc., and an “individual grade”, which tries to measure the knowledge gained by each student. Both ratings, together with the note of each practice session, give an idea of individual evolutions.

Innovative Education Projects (PIE)

Innovative Education Projects (PIE) are also useful tools the UCM has implemented for teachers to adapt subjects to the EHEA. They are developed along each academic year, by a group of University teachers. Occasionally, also students can participate. Due to these projects, we have produced useful and practical material for students and professionals. Initially, our aim was basically to facilitate the study of the Exotic Animal Anatomy in the Veterinary School. Then, we started to consider other collectives as biologists and zoologists. Because of this reason, our group includes a professor from the School of Biological Sciences, as well as other veterinarians and biologists working in different professional fields.

Results and discussion

The present paper describes some of our experiences on innovative education by using two useful tools: Pilot Subjects and Innovative Education Projects. It is, in summary, a comparison between tradition and innovation.

According to our results, pilot subjects have many advantages, but also some disadvantages. The advantages can be summarized in a positive and widespread acceptance of the system, a level of knowledge rather similar between students and the possibility of a close teacher-student relationship that is more complicated in the traditional teaching method. The disadvantages are the limitation in the number of students who can participate in this type of education, the need for greater flexibility in scheduling, and a greater investment

in infrastructure and personnel. These problems sometimes lead to a clear limitation for the development of many activities.

Concerning students' grades, it can be said that they are very similar. There are practically no differences between both methods. However, the motivation they have is much higher when there is a control on self-learning. Contrary to what happens with more traditional techniques, they enjoy studying and, which is even more important, they gain self-confidence and maturity.

We also analyze the role of Innovative Educations Projects in the implementation of Bologna Principles. It can be assessed that they are useful tools to adapt subjects to the EHEA. In our case, these projects have allowed an important evolution in the approach of Anatomy teaching, from being a traditional subject, towards a practical and directly applicable matter.

As mentioned before, our main interest at the beginning was to make the study of Anatomy simpler and easier (7) (Figure 1).

Our approach has evolved with time towards a "transversal point of view", which is also as an essential tool in the EHEA. The first step in this direction was to include a professor from the School of Biological Sciences, to expand our application to different subjects taught in this degree (8). For the first time, we started to have a more applied, less academic and more professional approach. Anatomy evolved from being a traditional subject, too theoretical and sometimes even tedious, towards a practical and directly applicable matter in the daily activities of a veterinarian or a biologist. Thus, we began to abandon the idea of "knowledge for knowledge", to give this knowledge a more practical sense.

From this moment we have never abandoned the principle of transversality as an essential basis for our work, always using the anatomy as the principal key key of other sciences: Radiology, Pathology and Internal Medicine (including Surgery], etc. (9 10, 11, 12 and 13). To increase the number of students and professionals who may have access to the results of our projects, in the past three years all PIE have been presented in English and Spanish (Figure. 2 and 3).

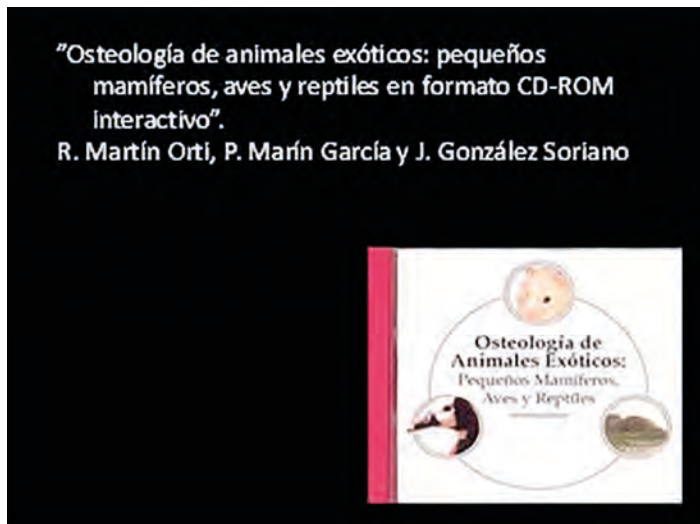


Figure 1. Cover of the DVD corresponding to the P.I.E. 2002/22 "Osteology of the exotic animals".



Figure 2. Example of P.I.E. 2010/98. Clinical case in a guinea pig. Note that Anatomy and Radiological Anatomy are also included.



Figure 3. Example of P.I.E. 2010/98. Clinical case in a snake. Note that Anatomy and Radiological Anatomy are also included.

The compendium of all these projects is UNICOMEX: a virtual space dedicated exclusively to exotic animals (Figure 4). In this occasion, we use the own Virtual Space of the Complutense University. Although the main axis is anatomy and clinical cases, the approach is completely open worldwide and dynamic, including links of interest, chats, quizzes, and so on. There is room for courses, with the corresponding self-assessment for students, resolution of clinical cases, and exchange of information with experts from around the world. In summary, the main goal is to give impetus to this new learning culture, which started years ago with the Principles of Bologna Treaty, to facilitate both academic performance and students' professional preparation. The work is presented in a dual version Spanish-English, useful both for students and professionals.

Conclusions

The present paper describes some of our experiences on innovative education, in a country which is very traditional, like Spain. Pilot Subjects can be used to compare tradition and innovation. They have advantages as a positive and widespread acceptance, a level of



Figure 4. Example of P.I.E. 2011/257. Home page in English and Spanish. Note that the Project acronym is UNICOMEX (University Complutense Exotics).

knowledge rather similar between students and the possibility of a close teacher-student relationship that is more complicated in the traditional teaching method. However, they also have disadvantages as the limitation in the number of students, the need for greater flexibility in scheduling, and the real need of a greater investment. These problems sometimes lead to a clear limitation for the development of many activities.

The *PIE* are also useful tools to go from a teacher-centered system to a student-centered system. In the case of the present authors, *PIEs* have allowed an important evolution in the approach of Anatomy teaching, from being a traditional subject, towards a practical and directly applicable matter. Another achievement is the use of Anatomy as the basis for other applied sciences a Radiology, Pathology or Internal Medicine. To promote dissemination of our results, the results are presented in English and Spanish.

References

- González Soriano J., Marín-García P., García-Moreno A. & Martín-Orti R. (2007). *La innovación educativa como herramienta imprescindible en la implementación del EHEA*. ISBN-3-9810562-0-5.
- González Soriano J., Marín-García P., García-Moreno A. & Martín-Orti R. (2007). *EL Espacio Europeo de Educación Superior, la creación de grupos multidisciplinares y la cooperación internacional*. Cursos de Verano de El Escorial. Universidad Complutense. Madrid
- Martín R. (2007). Anatomía de los Animales Exóticos: trayectoria de una asignatura innovadora. *Anales de la Real Academia de Veterinarios*, 15, 257-271.
- Aula Virtual Universidad Complutense. www.ucm.es/aulavirtual. Universidad Complutense. Madrid
- Martín-Orti R., Marín-García P. & González-Soriano, J. (2004). *Atlas de Anatomía de los Animales Exóticos y de Laboratorio*. ISBN 978-84-458-1406-2. Masson-Salvat.
- Martín-Orti R., Marín-García P., González-Soriano J. *Cuadernos Prácticos de Anatomía de los Animales Exóticos*. Cursos académicos 2006-07 [ISBN 978-84-690-4311-0], 2007-08 [ISBN 978-84-612-2221-6], 2008-09 [ISBN 978-84-92539-37-6]. Universidad Complutense. Madrid
- Martín-Orti R., Marín-García P. & González-Soriano J. (2003-2004). *Osteología de los animales exóticos, pequeños mamíferos, aves y reptiles, en formato CD-rom interactivo*. Universidad Complutense. Madrid.
- González Soriano J., García Moreno A., Marín García M.P., Martín Orti R. & Rodríguez Quirós J. (2007). *La anatomía clínica interactiva de los animales exóticos: un ejemplo de innovación*. Proyecto

de Innovación y Mejora de la Calidad Docente (PIMCD) n. 586. ISBN: 978-84-96704-29-9. Vicerrectorado de Innovación, Organización y Calidad. Universidad Complutense. Madrid.

González Soriano J., Montesinos Barceló A., Marín García M.P., Martín Orti R., Reh Aguirre de Cárcer B., García Moreno A., Alcántara de la Fuente G. & Pérez de Quadros, L. (2009-2010). *La innovación educativa aplicada a la anatomía y la clínica de las cavidades corporales de los animales exóticos*. Proyecto de Innovación y Mejora de la Calidad Docente (PIMCD) n. 167. ISBN: 978-84-96704-29-9. Vicerrectorado de Innovación, Organización y Calidad. Universidad Complutense. Madrid.

González Soriano J., Montesinos Barceló A., Marín García M.P., Martín Orti R., Aguirre de Cárcer B.R., García Moreno A., Alcántara de la Fuente G. & Pérez de Quadros, L. (2010-2011). *La innovación educativa aplicada a la anatomía y la clínica de las cavidades corporales de los animales exóticos. II*". Proyecto de Innovación y Mejora de la Calidad Docente (PIMCD) n. 98. Vicerrectorado de Innovación, Organización y Calidad. Universidad Complutense. Madrid.

González Soriano J., Martín Orti R., Aguirre de Cárcer B.R., Sarrate Santos F., Montesinos Barceló A., Alcántara de la Fuente G., Pérez de Quadros L., Camina Vega Á., Arencibia Espinosa, A. & Orós Montón J. (2011-2012). *Creación de un espacio virtual de Anatomía y Clínica de los Animales Exóticos*. Proyecto de Innovación y Mejora de la Calidad Docente. (PIMCD) n. 257. Ciencias de la Salud. Vicerrectorado de Desarrollo y Calidad de la Docencia. Universidad Complutense. Madrid.

González Soriano J., Reh Aguirre de Cárcer B., Marín García P., Sarrate Santos F., García Moreno A., Montesinos Barceló A., Alcántara de la Fuente G., Pérez de Quadros L., Camina Vega A., Arencibia Espinosa A., Orós Montón J. & Martín-Orti R. (2012). Virtual space for the anatomical and clinical study of exotic animals. In Gómez Chova, L., López Martínez, A. & Candel, I. (Eds). *INTED2012 proceedings 6th International Technology, Education and Development Conference*. Published by International Association of Technology, Education and Development (IATED). (pp. 6111-6116). ISBN: 978-84-615-5563-5.

González Soriano J., Reh Aguirre de Cárcer B., Marín García P., Sarrate Santos F., García Moreno A., Montesinos Barceló A., Alcántara de la Fuente G., Pérez de Quadros L., Camina Vega A., Arencibia Espinosa A., Orós Montón J. & Martín-Orti R. (2012). *The anatomical and clinical study of exotic animals in a web site*. Conference proceeding. The Future of Education International Conference. Florence.

EDUSCIENCE PROJECT – EFFECTIVE WAY OF TEACHING NATURAL SCIENCES AT POLISH SCHOOLS

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Abstract – Lessons at Polish schools are generally not innovative, conducted traditionally, often without individual approach to pupils and their interests and talents. Study programmes and specializations chosen by young people do not coincide with the real needs of the existing industries and the market. It is evident particularly in the shortage of qualified graduates in science. New methodology concerning multiple intelligences approach with the usage of IT and combining research passion of scientists of Polish Academy of Sciences, proposed in the Eduscience project, gives the chance for diametrical change of the situation.

Within the project first evaluation research was conducted on September 2011 (CAWI – Computer Assisted Web Interviews completed by 175 respondents). Another study evaluation was performed in 2013 using several methods and diagnosis techniques: 40 In-depth interviews (IDI), 8 Focus group interviews (FGI) and 3 Interviews conducted via Internet (CAWI). Conclusions drawn from the studies show that techniques and methodology proposed in the Eduscience project are adequate to improve pupils interest in learning natural science.

Keywords: teaching of natural science, scientific approach in education, accelerated learning, e-learning platform, scientists at school.

Introduction

Popularisation of Earth sciences among the society and school students has always been an important aspect of the activity of the Institute of Geophysics PAS. The Institute has been taking part in many scientific events. The scientists are often asked by the media to comment current events related to the Earth's activity, like earthquakes, tsunamis or eruptions of volcanoes. For many years the Institute has been offering classes in the "Geophysics at school" project. The project's primary goal is to popularize geophysics (geography, geology and physics), by providing lectures, presentations and workshops for students of lower and upper secondary schools.

Since March 2011 the Institute is also the leader of the project "Improving students' competences in science and mathematics by employing innovative methods and technology – EDUSCIENCE". The project is carried out within the Human Capital Operational Programme and is co-financed by European Union within the range of European Social Fund. It is the biggest Polish innovative project in the field of education. The main aim of the project is to rise the interest in mathematical-natural sciences among schoolchildren, what would lead to an increase in the number of young people deciding to study subjects related to those sciences. That is also very important from the point of view of Poland's economy, which needs more young specialists educated in those fields. The aim is being achieved by designing, development, pilot implementation and promotion of innovative

school syllabuses with the use of an interactive e-learning platform.

Eduscience's background

Lessons at Polish schools are not innovative, conducted traditionally, often without individual approach to pupils and their interests and talents (Szafraniec, 2011). In addition, the present system of education is aimed at preparing students for external examinations, which forces teachers to be focused on communicating the facts rather than on teaching useful skills, thinking and research approach to problem solving. Such a non-comprehensive approach to the issue of effective teaching strategies is observed at all levels of education.

Moreover, terms of teaching created by today's schools do not promote a complete development of the child and are detached from the rapidly changing reality that young people have to face. It led to a huge gap between the student's personal knowledge and the knowledge acquired at school. Yet learning can be effective only when it is closely linked to the recent demands of the market. Today's world has high expectations towards young people – they have to be up to date with all the new inventions and discoveries, be able to think independently and make many different decisions at the same time (Lotkowska et al., 2012).

New methodology concerning multiple intelligences approach with the usage of IT and combining research passion of scientists of Polish Academy of Sciences, proposed in the Eduscience project, gives the chance for diametrical change of the situation. Project Eduscience changes the process of learning as such: it takes into account individual learning styles (methods of learning), it encourages an individual approach to the process of learning by accelerating the process of understanding and memorizing and also by integrating knowledge and skills according to one's individual learning techniques. Teaching methodology used in the Project is based on the innovative approach to the learning process and pedagogy as such. It takes into account newly discovered abilities of human brain and perceives the process of learning in psychological terms.

Final product of the project

The most important product of the project is e-learning platform, which contains lessons and materials on mathematics, physics, geography, biology, chemistry and polar research, prepared by scientists of 4 institutes of Polish Academy of Sciences i.e. Institute of Geophysics, Institute of Geological Sciences, Institute of Oceanology and Space Research Center, and also Gdynia Maritime University. The pupils have the possibility to participate in on-line classes taking place in geophysical Observatories. Some lessons are transmitted from the research vessel "Horyzont II", where the schoolchildren have an unique and direct contact with science. There has not been a single educational project in Poland on natural science so far, which gives such an opportunity to become familiar with the fascinating world of science "live".

All the activities lead to use and implement the newest science concerning the brain structure and the needs of a man and also to stimulate him/her to be active and researchful. Therefore the teachers are equipped with the modern and efficient work-with-the-pupil methods worked out together with British partner in the project (Accelerated Learning Systems Ltd.). The e-materials are compatible with multimedia boards, which make the process of learning more attractive.

The main elements brought into the learning process within the Project are: demonstrating various scientific experiments as practical applications of scientific knowledge, using different materials on the platform (via Internet) including: videos from scientific expeditions, audio files, teleconferences with scientists, transmissions of experiments and research performed by scientists, science Festivals and Eduscience picnics organized in various parts of Poland, which give the opportunity to see and perform scientific experiments and to get involved in the world of science in an entertaining way.

Methodology

Within the project first evaluation research was conducted on September 2011 (CAWI - Computer Assisted Web Interviews). Interviews were based on a standardized questionnaire containing a set of 17 questions (both open and closed). The main aim of the study was to diagnose the state in the field of teaching mathematics and science before implementation of the Eduscience Project. The survey was completed by 175 respondents - teachers, school practitioners at all levels of education. Another study evaluation was performed using several methods and diagnosis techniques: 40 In-depth interviews (IDI) - with teachers and students of the third and fourth educational stage, 8 Focus group interviews (FGI) with teachers and students of the third and fourth educational stage and Interviews conducted via Internet (CAWI) with students, concerning level of implementation of the main and specific objectives of the project.

Results and discussion

The major conclusions that derive from the first part of the study, realized in September 2011:

- The interest in mathematics and science should be assessed as inadequate in the context of the number of graduates with the skills demanded by the market.
- Holistic approach towards the process of learning and application of modern facilities and special equipment in the classrooms have a significant impact on students' interest in mathematics and natural sciences.
- Teachers tend to provide passive classes that do not encourage the student to participate actively in the lessons. There is no contact of the student with a real science. The student often does not take part in the research process or in the experiment performed by the teacher – he or she remains just a passive observer.
- Skills in synthetic and analytical thinking among male and female students differ and are generally low.
- Availability of interactive materials that could increase the attractiveness of a course or class has been rated as unsatisfactory.

The study in 2013 was performed to obtain better understanding of the problem of low interest in mathematics and science among pupils. From interviews the conclusions were drawn that most of young students perceive mathematics and science as difficult and tiresome rather than interesting and worth attention (Evaluation study, 2013).

The persistent disparities in the perception of mathematics and science between primary and the following stages of education were confirmed. With the transition to the next stages of education, interest and understanding of mathematics and natural science subjects suddenly declines. This dramatic change in the approach towards certain subjects is confirmed by most of the teachers. The respondents often indicate that in the first stage of education (initial year of primary school) children are keen to explore new ideas and facts presented by the teachers and are really willing to learn, they are vividly interested in mathematics and science. It is important to note the fact that children learn with all their senses – they learn by being in contact with new ideas, things and phenomena. They learn something concrete – not abstract, as it is at higher educational stages.

Teachers also point out that children often lose interest in mathematics and science mainly due to the early failures, which tend to accumulate with the transition to higher stages of education. At the same time the curriculum becomes more and more difficult. This tendency applies mainly to mathematics. If young students show their interest in mathematics and science, they justify it to logic and simplicity, identity with personal interests or career/educational plans, no requirement to study “by heart”, opportunity to experience something personally (experiments) or usefulness in life and further education (Evaluation study, 2013).

At schools, which take part in the project visible changes concerning didactic methods proposed by teachers were observed: the usage of film and audio files and multimedia presentations has increased significantly. As interviewees indicated, more children enumerate also school trips and work in groups as an effective method of learning. Pupils were glad also to take part in plays and games, which possibly was related to the usage of the Eduscience e-learning platform that enables the teacher and the student to use it as a method of learning.

Conclusions

Conclusions drawn from the studies show that techniques and methodology proposed in the Eduscience project are adequate to improve pupils interest in learning natural science. Lessons, materials and IT-tools proposed in the project are considered by teachers and pupils as interesting, involving and more attractive than normal curriculum.

At present the project is being held at 250 schools in Poland chosen at random on all levels of education. After the final evaluation process on June 2014, the e-platform, containing all the educational tools and materials created during the project, will be available on-line at no cost to all Polish schools.

References

- Lotkowska K., Stankiewicz P. & Juńczyk T. (2012). *Eduscience Information Biulletin*. Ed. Institute of Geophysics PAS, Education Pro Futuro, American Systems. Warsaw, Poland.
- Evaluation Study within the Project “Improving students’ competences in science and mathematics by employing innovative methods and technology – EDUSCIENCE” – mid-term report, 2013, (not published). AMS, Kutno, Poland.
- Szafraniec K. (2011). *Youth 2011*. Warsaw, Poland.

“WHO WANT TO BE A WEATHER FORECASTER?” EDUCATION AND PUBLIC OUTREACH AT LAMMA CONSORTIUM, HOME OF TUSCANY WEATHER SERVICE

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Abstract – Research institutions can play an important role in the overall education system. This paper aims at presenting educational and public outreach activities in the field of meteorology carried out by LaMMA, a public consortium set up by Italian National Research Council and Tuscany Region (Italy), in charge of the official weather service for Tuscany. Here a description of the activities and different learning opportunities is provided. The paper also presents the results of the evaluation survey carried out to assess the quality of the learning activities offered to schools. Moreover the survey had the goal to collect feedbacks from pupils about interest, efficacy and satisfaction about the education proposal. The high numbers of pupils reached, about 1500 in 2011-12 visiting LaMMA Consortium, and the evaluation results, confirm the great interest and importance of educational activities provided by science centres at local level.

Keywords: education in meteorology, evaluation, outreach, science education

Introduction

Science centers and museums can play an important role as informal science education places, contributing to increase science awareness of local communities. They represent a great opportunity for schools' visits, but also can help general public to increase knowledge about science (Mintz, 2005). When visiting science centers people have the chance to see science laboratories and meet researchers doing science. Through outreach programmes and activities many science centers offer kids and adults the opportunity of learning science by doing. They provide a “rich learning environment” that can inform classroom practice (Dusenbery, 2008).

LaMMA, Environmental Modeling and Monitoring Laboratory for the sustainable development, in charge of regional weather service for Tuscany provides general public with reliable weather forecast as to inform them and let them make informed decisions. Due to the increase availability of weather information, pushed also by the rapid growth of mobile devices, the ability to understand weather forecast is becoming more and more relevant for general public. The increasing *interest* in weather forecast does not necessarily correlate to an increase in *understanding* of the forecast. That is why it is so important to invest in educating the public to the understanding of meteorology and to help them to correctly make sense of weather information. This is even more true if we consider the increasing

occurrence of severe weather events who often put at risk communities, either people and commodities.

In recent years LaMMA Consortium invested time and efforts to set up outreach and education activities in meteorology and climate issues as to increase awareness of Tuscany communities on this subject and improve their resilience face to weather related emergencies.

LaMMA Consortium, home of the weather service in Tuscany

The LaMMA Consortium, (www.lamma.rete.toscana.it), is a public consortium set up by Italian National Research Council (hereafter CNR) and Tuscany Region, which combines CNR's scientific research skills with the administrative body's commitment to public service, to develop products and services on environmental monitoring. LaMMA is in charge of the Tuscany weather forecasting service, which constantly monitors atmospheric conditions and produces daily reports 7 days a week. In addition to regional weather bulletin, LaMMA also provides "customized" services, with weather reports specifically designed for different categories of users and delivered through different media. Though operative, LaMMA is a scientific research body, part of Italian CNR, and research mission embraces all its spheres of activity.

LaMMA is located near Florence, within the local CNR Research Area. It was funded in 1997 as research laboratory specialized in remote sensing and environmental modeling. Some years later researcher started the first weather bulletin for Tuscany region.

Education and outreach

The LaMMA Consortium provides environmental education and scientific information activities for primary and secondary schools in Tuscany, both in the form of specific projects and in response to requests from particular schools, with lessons arranged at the schools themselves or at our offices. The scientific and environmental information activities involve research sectors linked with meteorology, climatology, remote sensing, oceanography, the carbon cycle, biometeorology, energy saving and environmental sustainability.

In these spheres of activity, LaMMA, in collaboration with CNR's Institute of Biometeorology, offers a range of opportunities to get involved, in response to the different requests from schools. A few examples:

- *Explanatory lessons*: for many years, researchers from CNR and LaMMA have been offering educational activities for classes that request them. Lessons take place either on our premises or in the schools' own classrooms, and are structured so as to allow the pupils to take an active part.
- *Training seminars for teachers*: on our own initiative or as part of financed projects, meetings and seminars have been organized for secondary and tertiary teachers on the themes of meteorology, climate change, the carbon cycle, and environmental sustainability in general.
- *Production of teaching materials*: as a result of our educational activities, various printed and digital materials have been developed to support teaching on the scientific topics covered. Some of them can be downloaded from our Teaching materials page.

- *Laboratory visits*: many schools ask to visit the LaMMA laboratories, and in particular the Meteorology Room, in the Research Area of the Science Complex in Sesto Fiorentino, where students can meet the meteorologists and see for themselves how the weather forecasts come about.

Besides activities for school LaMMA also carried out other outreach activities, like open days and science festivals. Following some examples:

- *participation in science and environmental festival*: during last years LaMMA researchers in collaboration with CNR's Institute of Biometeorology participated at the Science Festival in Genoa, the most important festival on science and technology organized at national level, and to the European Night of Researchers "LIGHT – Turn on the light on science". Arguments of the researcher proposal were very often linked to weather and climate, issues considered very engaging for the great public. Interactive laboratories and conferences were organized dealing with the carbon cycle and its connection to climate; climate change impacts in different part of the world; climate change mitigation efforts and sustainability good practices and lifestyles. A topic of major interest is always that of weather forecasting techniques and technologies. A typical outreach activity organized in various festival is in fact the installation of a weather station showing real time data. This activity made with a researcher or a forecaster have encountered the appreciation of the public, interested in understanding the functioning of the essential element of the weather forecast and bulletin.
- *Open day*: each summer the Research area of the Science complex of the University of Florence organize an open day for the general public "ScienzEstate". It's a day where all the labs are open and researchers are happy to welcome visitors to show everyday activities and engage students, kids and families in science and technology. LaMMA always takes part in such events offering visits to show to public the forecast operating room.

LaMMA educational offer

Science institutions can play an important role in the overall educations system, providing students and teachers with different opportunities of learning (Boer 2008; Dusenbury 2008; Rosendhal 2004). This is even more true when science centers realize opportunities to visit laboratories or design activities based on learning by doing.

Since its very beginning as regional weather service, LaMMA forecaster have been asked to participate in learning activities by school teachers in Tuscany. There was no structured educational branch or personnel it was more an activity on request, carried on by a small group of people who were passionate about that and considered science education and meteorology as an important issue for a research institution. Educational activities, mainly organized as lessons in classrooms, increased during the following five/ten years contributing to widespread the LaMMA "brand" within Tuscany. It also pushed researchers to produce educational materials to be showed during lessons, contributing in this way to the "informal" institutionalization of education and outreach activities for LaMMA. Due to a renewed communication strategy and mainly to the brand new web site articulated in different sections, in 2010 LaMMA decided to play a more active role articulating an educational proposal for schools of the different grades, as to meet the students background, and to give more visibility to this branch of activities. In the new web site a section was dedicated to "Education", presenting the opportunity offered to schools for

visiting LaMMA, offering some electronic booklets and publications realized in previous projects by colleagues of Ibimet CNR, on climate, climatic changes and sustainability. Some pages were also dedicated to show pictures and videos realized by students to get attention of students on LaMMA web site. The brand new LaMMA Facebook page was also thought to meet this goal.

In the last three years an offer on meteorology education was set up. Mainly it was articulated into three main modules: “Basic weather”, a lesson to present main concepts of meteorology and explain how daily weather bulletin is produced by LaMMA; “Weather for Kids”, to introduce young children to weather issues; “Who want to be a forecaster”, a more participative lesson with a two-fold goal: help students to realize a weather forecast and communicate it through a video. In the last two years another proposal was added: “What’s up there?”, to present basic concepts of meteorology and simple physics principles through live experiments run by researchers. All the four modules are organized on a two hours time length and include the visit to the forecast operating room.

Following, a more detailed description of the activities run in the four modules.

1. “*Weather for Kids*”: it’s a first approach to meteorology for little children aged 4-6 years and it’s delivered in a light and funny approach. The idea behind is to help children to recognize main weather conditions and connect them to icons they see on the weather bulletin. The icons representing main weather conditions are disclosed and illustrated to children (sunny, partly cloud, cloudy; rainy; stormy, snowy). Afterwards, they’re invited to realize their own bulletin. Sketched weather icons are provided to children to be colored, cut and pasted on a big sketch of Tuscany region. Kids are eventually asked to present their bulletin to researchers and to pairs and may also bring it home to show parents. A demonstration of the functioning of a weather station completes the lesson, with researchers explaining basic measurements and data.
2. “*Basic weather lesson*”: it’s usually proposed to students of elementary school (first level of education, K-10) and to first years of secondary school (second level of education, K-14). It’s structured with a first part with a presentation of main meteorological concepts (atmosphere composition; altitude and temperature; water cycle; clouds composition and rain; thermal conditions and winds; wind patterns). A brief description of main weather conditions in Tuscany is provided. The lesson is completed by a presentation of the key steps of the forecast activity run by LaMMA Consortium meteorologists: relevant observations (ground measures; satellites and radar data) and the weather-marine models available at LaMMA (both global models and regional models at higher resolution). Special attention is addressed to illustrate LaMMA mission as regional weather centre for emergency and civil protection. The aim is to raise awareness about the difference between commercial weather services and institutional ones, the last ones being in charge of the issuing of weather alerts within the complex system of civil protection. In the second part of the meeting students are invited to explore the functioning of a weather station and to visit the forecast operating room, where LaMMA meteorologists broadcast the morning weather forecast. The learning goal of this module is to illustrate basic elements of meteorology and raise awareness on the different components of the works of the meteorologists. Slide show and videos are the main instruments used to run the lessons, together with the visit to the laboratories.
3. “*Who want to be a forecaster*”: this is usually proposed to students aged 14 years or older. It’s a more interactive module where students have to realize their own weather forecast

on video, using an active learning approach (Bonwell and Eison, 1991). In the first part of the lesson there's a presentation of the key steps, instruments and technology used by forecaster for the daily activity: reliable observations (ground measures; satellites and radar data); output maps of atmospheric and marine numerical models that simulate weather and marine conditions at different temporal steps on different areas at various resolutions, from today up until +72 hours; the essential work of interpretation made by the forecaster. A special attention is also given to the presentation of the different and complex aspects of the communication of the weather forecast: different videos of weather bulletin, Italian or foreign, old and recent, are showed. The goal is to make students aware of the communication process behind a weather bulletin, the challenge to be precise but at the same time use a clear and plain language. Students are thus asked to realize their own weather forecast in working group of 4/5 units each. They're provided with a computer per group and a slide presentation they've to complete. These slides are the video support during the recording of the weather bulletin and are articulated in such a manner: the first slide shows a MeteoSat animation of the morning satellite view, actually used in the official weather bulletin; the following two slides present the layout of the regional bulletin they have to fill in choosing from a set of predefined icons. Besides they're also asked to imagine the context of the bulletin they're presenting: whether it is the regional service, the school weather channel, the weather forecast for local soccer team or whatever they like. Choosing the context and the video format it's critical for writing the texts of the forecast, the language choices, the use of jargons and the whole communication style. This module has the aim to make them more aware of the communication context and processes in which a weather bulletin is inscribed. The learning goal is therefore more directed on raising awareness on the whole forecasting practice than increasing students knowledge of meteorology.

4. "*What's up there*": this module is proposed to elementary students aged 9 up until 15 years old. The core of the lessons is represented by some experiments performed by two researcher who use basic physics' experiments to explain main concepts of meteorology. Students are only spectators, do not interact directly with the experiment but only for very simple actions, but are involved in the scientific process due to researcher approach bases on inquiry based learning. New knowledge and concept are in fact introduced by researcher only afterwards the performance of the experiment and following the students spontaneous formation of the possible hypothesis explaining the scientific basis of experimentation. In the second part of the module students are invited to visit the weather operational room and see the functioning of a weather station. The execution of experiments is very effective from the didactic point of view, especially with younger people, as it stimulates their natural curiosity directing it towards the scientific approach, with the formulation of appropriate questions and verification of possible answers. More than on simple transmission of key concepts this module aims to spark interest in the students and make them passionate in science.

Evaluation

If evaluated in terms of number of attendance, the educational activities by LaMMA certainly turn out more than satisfactory. The last three years have seen an important increase

in number of students participating in LaMMA education proposal: only during the school year 2011-2012 we have achieved more than 2000 students reached with in-house education offer and outreach events. Only in the last three years about 150 hours of lessons; more than 320 minutes of video recorded by students playing of a weather forecasters on video.

To assess the outcomes of the educational activities an evaluation was set up by LaMMA researchers, starting from 2011-2012 school calendar. The evaluation had the main purpose to measure the level of satisfaction of the students involved in educational activities on meteorology. Instead, the analysis wasn't meant to assess the eventual change in science knowledge and competences of students attending the lessons.

A single sheet questionnaire was set up and distributed to students at the end of the education activity in LaMMA inviting teachers to supervise that students would be filling it once back to school. The survey was anonymous for students who had only to mark their school and class. The questionnaire was structured with six closed-ended questions and three open-ended. For the closed-ended a Likert scale on a response scale 1-to-5 was chosen to rate each item, choosing amongst "very good", "good", "sufficient", "poor", "very poor". Participants were asked to evaluate the following six themes:

- the meeting as a whole
- whether the lessons were engaging and stimulating
- the level of new knowledge acquired
- the interest increase on the topics covered
- whether the presentation was clear and easy to follow
- the facilities provided by LaMMA's headquarter.

The primary reason we used the Likert scale was to have data easy to code and report back by simply assigning codes to the responses. To give also a certain room to respondents feedbacks, three open-ended questions were included: what they did like; what should be improved; free comment.

Results and discussion

The data we present here are relative to the survey run on students visiting LaMMA laboratory during 2011-2012 for the weather education module. Starting October 2011 till June 2012 LaMMA received around 1500 students in its laboratories. Questionnaires were delivered during the visits to teachers who were asked to make the students respond and deliver the filled survey back to LaMMA. Out of 1500 questionnaires delivered, 731 returned back and have been analyzed.

The main results are presented.

A first analysis was run to determine the geographic distribution of schools per county (Provincia). Majority of students coming from Florence County (59%), followed by Prato and Lucca (9%), Arezzo (8%), Pistoia (8%) and Pisa (7%). As for the level of education, 25% of students were coming from elementary school, a 46% from secondary school and 29% from high school. Such simple statistics are summarized below in figures 1 and 2.

For the six closed-ended questions with Likert scale, results were elaborated assigning a point 1-to-5 to rate each item, starting from 5 for "very good" to 1 for "very poor".

Table 1. Geographic distribution of students visiting LaMMA's headquarter during the school year 2011-2012.

COUNTY	PERCENTAGE
Firenze	59%
Prato	9%
Lucca	9%
Arezzo	8%
Pistoia	8%
Pisa	7%

Table 2. Distribution of students visiting LaMMA's headquarter during the school year 2011-2012 on the basis of level of education (Elementary school K-10, Secondary school K-14 and High school K-18).

LEVEL OF EDUCATION	PERCENTAGE
Elementary school	25%
Secondary school	46%
High school	29%

In its complex the survey gave very positive feedbacks, where average values were as follows:

Table 3. Average point of the closed-ended questions.

CLOSED-ENDED QUESTIONS WITH LIKERT SCALE (1-5)	AVERAGE
What is your opinion on the lessons attended?	4,3
The meeting was addictive and challenging?	4,1
Did you learn new things?	4,2
The meeting has increased your interest on these topics?	3,7
The arguments were expressed in a clear way and easy to follow?	4,0
What is your opinion on the facilities of LaMMA?	4,4

No big differences in the results occur when analyzing the survey on the basis of the level of education of pupils. Most of the attendants (> 90%) rated their overall experience "good" or "very good". Nevertheless when analyzing the survey on the basis of the educational module offered, small but significant differences arise. In fact for the module "Who want to be a weather forecaster", which is based on a learning by doing approach, almost the total number of pupils (97% out of 182 surveys) rated it "good" or "very good". While for the "Basic weather lesson" and for the "What's up there" modules highest rates were assigned only by the 90% of the sample, where "medium" reached about 7%, "good" about 50%, and "very good" about 40%.

Finally, the open-ended questions were elaborated with a word clouds software to determine the most occurring words. This helps to give an idea of the most common feedbacks received from students. Word clouds were realized with an online tool on the web site <http://www.wordle.net/>, a generator of word clouds based on the principle that words occurring more frequently has greater prominence.



Figure 1. Word cloud of the answer to the question "Write what you liked more".



Figure 2. Word cloud of the answer to the question "Write what should be improved in your opinion".

that science can be “fun”, thus encouraging students’ choice towards careers in STEM (science, technology, engineer, mathematics). The appreciation of LaMMA educational offer is confirmed by the great number of requests from schools to follow weather modules. This positive has also been confirmed by the output of the evaluation survey carried out on a sample of more than 700 students. Further investigations are still ongoing in order to understand the hidden feedbacks contained in the surveys (especially in the open-ended questions), to improve the educational offer and meet more specifically the needs of the public visiting the LaMMA laboratory. Even in a lack of institutional budget for communication activities in general, LaMMA strives to maintain its proposal in order to offer to citizens and schools an opportunity of science education of high profile and free of charge.

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The educational activities carried out by LaMMA are not economically sustained by any financing or dedicated incomes. These have made been possible thanks to the commitment of many people from LaMMA, directly and indirectly involved, namely: Bernardo Gozzini (Sole Director), Susanna Lotti, Simone Montagnani, Lorenzo Giannelli, Elena Cristofori, Valerio Capecchi, Giulio Betti, Claudio Tei, Tommaso Torrigiani, Giorgio Bartolini, Francesco Piani, Riccardo Benedetti, Andrea Orlandi, Federica Zabini, Ramona Magno, Valentina Grasso. A special thanks also goes to Matteo Biagini, an eager student of “Alessandro Volta” High School in Florence, who carried out part of the data enter during an internship at LaMMA in June 2012.

References

- Bonwell C. & Eison J. (1991). *Active Learning: Creating Excitement in the Classroom*. AEHE-ERIC Higher Education Report No. 1. ISBN 1-878380-08-7. Jossey-Bass, Washington, DC.
- Boer M. (2008). Current and future activities in education and public outreach at the Observatoire de Haute Provence. *Advances in Space Research*, 42, 1831-1836.
- Dusenbery P.B., Harold J.B., McLain B. & Curtis L. 2008. Space Weather Outreach: An informal education perspective. *Advances in Space Research*, 42, 1837-1843.
- Mintz, A. (2005). Science, Society and Science Centers. *Informal Learning Review* 71, Washington. DC.
- Rosendhal J., Sakimoto P., Pertzborn R. & Cooper L. (2004). The NASA Office of Space Science Education and Public Outreach Program. *Advances in Space Research*, 34, 2127-2135.

FROM SCHOOL TO UNIVERSITY: A ROUND TRIP

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Abstract – The most motivated and skilled students are involved together with their teachers to practice and become familiar with Bioscience teaching-lab modules. Teachers and students, together, attend a training course for developing the theoretical and practical activities in order to propose them to peers at school.

Keywords: Bioscience, IBSE approach, peer education, citizen science, technology and multimedia.

Introduction

Responding to the high-school teachers' need to receive training and swap advice in the latest scientific developments, the University of Milan in May 2004 has founded CusMiBio (Centre of the University and School of Milan for Bioscience Education, www.cusmibio.unimi.it), whose aim is to improve Bioscience Education in High Schools. CusMiBio works in close collaboration with the Lombardy Educational Office. This center wants to be a bridge between two educational systems, High School and University, that often do not interact with each other. The CusMiBio main goal is to increase in High School students the knowledge and interest in Biosciences and to help their science teachers in keeping up with the rapid scientific advances in life sciences and in biotechnology. The main problems for both teachers and students are old text books, insufficient time to cover important topics, a lack of practical experiments and limited students' interest who often perceive biology as a "soft science". Therefore, teachers need to regularly update their knowledge and skills, and develop new methods to actively involve their students. This requires new, discovery-based curricula making science more appealing.

Establishing functional and synergistic links between high-school teachers, students and Universities is one way to do this. Of course, students need a basic knowledge but, to capture their interest and curiosity, it is also important to expose them to cutting-edge research and to give them the opportunity to experience the excitement of working in a research laboratory. The three main players – high-school students, science teachers and researchers – must learn to interact with each other to forge links between schools and universities. This close cooperation eventually generates a virtuous circle: researchers and teachers identify and propose scientific topics that can be discussed in the classrooms and lead to related experiments; together, they develop theoretical and practical activities able to stimulate students' curiosity and, in turn, urge their teachers to acquire additional knowledge.

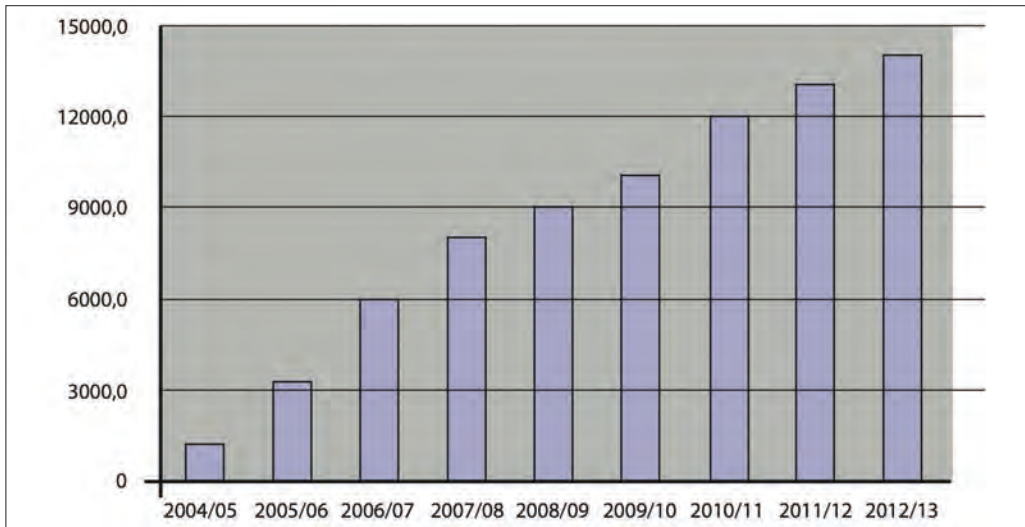


Figure 1. Number per year of high school students taking part, every day, in “Try the BioLab” activities.

One of the most important and appreciated CusMiBio activity is “Try The BioLab”, hands-on research activities in the Lab: an entire class with its teacher perform such activities on some hot topics in genetics and molecular biology under the supervision of a lead teacher (High School teacher trained in CusMiBio) and young tutors (~ 13.000 students (Figure 1) attend these activities in the last year).

The approach is authentically IBSE: students and teachers experiment together scientific activities in a university setting, discussing and critiquing procedures and results with professionals (tutors & post-docs). We think that letting students “discover” things – rather than just learning about them – can greatly improve their understanding of the basic biology concepts.

Topics of the lab activities are: DNA Fingerprinting, GMO, Genetics and disease, Bacterial transformation, Chromosomes analysis, Bioinformatics tours, DNA barcoding...

Several “Try the Biolab” activities are suitable for being transferred to schools as “Teaching Kits” (Figure 2). So, in 2011/12, CusMiBio started the project “From school to University: a round trip”.

In this project, the most motivated and skilled students are invited together with their teachers to practice and become familiar with these teaching modules. Teachers and students, together, attend a training course to acquire the necessary theoretical background and they become expert in proposing practical activities to peers at school.

Methodology

Organize courses for teachers and students in molecular biology, genetics and bioinformatics, combining cutting-edge science with experimental activities.

Create working groups of High School science teachers, students and university researchers, to develop IB learning modules on advanced Bioscience topics and verify the feasibility of their transfer to the Italian school system.



Figure 2. An example of lab equipment inside “Teaching Kit”, useful to transfer some “Try the Bio-Lab” activities in school laboratories.

Prepare educational kits (equipment, materials, handbook, protocols, teacher’s guide etc.) that can be carried and used in schools.

Results and discussion

- Promoting a more participated, inquiry-based approach in High School science education
- Improving knowledge to manage the topics with the required competence
- Creation of the most favorable conditions for cooperation within and between schools and between teachers and students (Figure 3)

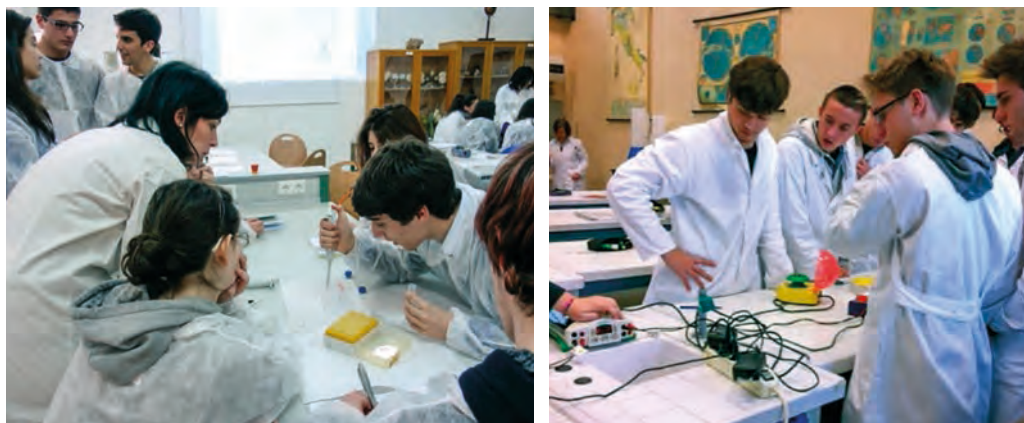


Figure 3. Two different situations of “From school to University: a round trip”; in the left one, students with teachers and university researchers are preparing and evaluating lab activities; in the right one the well-suited lab activities are recreated in school.

- Supporting students in conscious planning of their future studies
- Promoting and favouring the outgrowth of the most talented students and ensuring a new generation of researchers
- Exchanging materials and experiences.

City Barcode Project

Another aspect and natural outreach of these activities is the *City Barcode Project* (CBP).

Science education is traditionally accomplished in the context of “canned” labs with known outcomes. However, science educators are looking for innovative ways to implement open-ended, “authentic” research projects that engage students in all aspects of scientific inquiry. CBP is a pilot project to demonstrate the feasibility of implementing large-scale, distributed experiments in DNA barcoding within the context of a major urban school system. By organizing the CBP, a relatively large numbers of students can have a meaningful experience with authentic scientific research. Barcoding is a hands-on experiment that allows teachers and students to work with high-level biotechnology, and it extends techniques, tools, and skill sets common to many fields in biology. Teachers who have been traditionally focused on abstract or concept-dependent biological disciplines (including genetics, taxonomy, and ecology) find DNA barcoding a non-intimidating innovative way to teach molecular biology and one of its applications. The city barcode project urges the students in studying biological diversity in their own urban environment and encourages them to consider the diversity of other living forms and products in their parks, homes, restaurants, and stores.

This project is in the core of “citizen science,” where non-scientists can contribute data that is potentially useful to scientists. DNA barcoding is intrinsically interesting to teachers, as it is a natural complement to the concepts covered in the Biology and Environment curricula. The protocols developed for the City barcode project are low-cost, can be completed within 3 hours, i.e. one afternoon, (not considering the time spent on sample collection and DNA sequencing), and are highly robust (Fig. 4). Despite the modest lab commitment, DNA barcoding offers to the students the opportunity to engage themselves in original

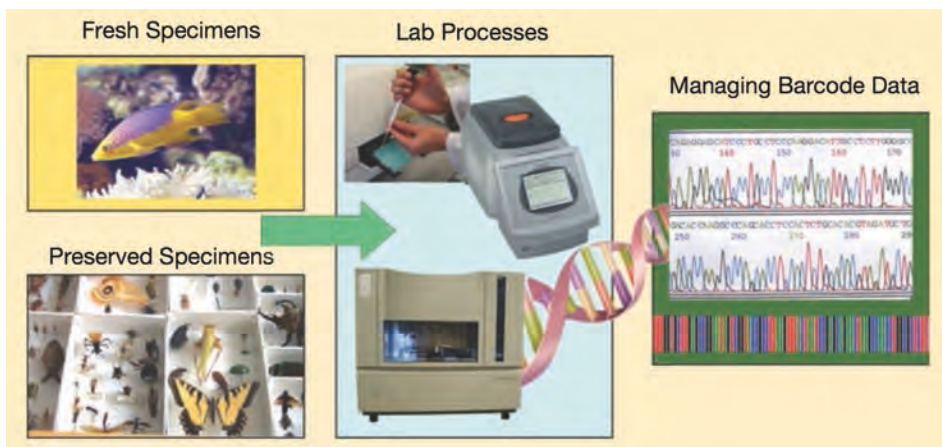


Figure 4. DNA Barcoding activity: from collecting specimen to analyzing DNA sequences.

research. This will be a chance for teachers and their students to obtain DNA sequences related to questions and projects of their choice.

Methodology

Taxonomy identifies and organizes species into groups based on shared features. Understanding how millions of organisms contribute to our planet ecosystems requires that we are able to identify and name them. Until recently, all taxonomic classification required experts capable of subjectively evaluating the few and sometimes subtle differences between two species.

This totally changed with DNA barcoding, which allows non-experts to make an objective identification of a species. Just as the unique pattern of bars in a universal product code (UPC) identifies each consumer product, a DNA barcode is a unique pattern of DNA sequence identifying each living organism.

DNA barcoding is based on the sequence of specific genes previously identified as suitable barcode markers. The sequence of such genes sufficiently differs between species (inter-species), so that any identified sequence can be precisely assigned to a species. Molecular biologists have identified the CoxI gene in mitochondrial DNA (encoding cytochrome oxidase I) as the gene able to satisfy the requirement outlined above. For plants, barcoding a region of the chloroplast gene *rbcL* (RuBisCo large subunit) is normally used. With thousands of copies per cell, mitochondrial and chloroplast sequences can readily be amplified by polymerase chain reaction (PCR), even from limited or degraded specimens.

Guidelines

Teachers who want to participate in the CBP must attend a DNA-barcoding workshop. Science teachers at school have to encourage students to consider the diversity of living organisms and products in their parks, homes, restaurants, and stores and they propose a project. Submitted CBP proposals will be evaluated by CusMiBio researchers for their feasibility, originality, and level of creative thinking.

Selected projects and teams will have to go through the following steps:

- Step 1 (at school): introducing students in the design of a DNA barcoding experiment;
- Step 2 (in the field): assisting students in sample collection, in how to preserve the specimen and in providing geographical and environmental documentation;
- Step 3 (at CusMiBio Lab): to extract and purify DNA from tissues or processed materials. To amplify a specific region of the chloroplast or mitochondrial genome by polymerase chain reaction (PCR), and analyze PCR products by gel electrophoresis. CusMiBio will provide the equipment and reagents for these experimental steps. (some schools may have the needed equipment and will require only the reagents to perform this part of the experiment in their labs). The amplified sequence will be submitted for sequencing to a collaborative CusMiBio partner;
- Step 4 (at CusMiBio bioinformatics lab): DNA sequencing data will be analyzed with the support of the CusMiBio staff:
 - to search the Barcode of Life Data System (BOLD), using the Basic Local Alignment Search Tool (BLAST);

- to analyze phylogenetic relationships, using multiple sequence alignment and tree-building tools. To this aim, the DNA Learning Center (DNALC), a collaborative lab located in Cold Spring Harbor, NY, USA, has created a simplified bioinformatic platform, specifically designed and adapted for the US Urban Barcode Project. DNALC has authorized CusMiBio to use the platform and gain access to the barcode database. Results will be discussed.
- Step 5: Students have to write a final report which includes: a) an Introduction with a survey of the current barcoding literature; b) a section, providing the goals and approach of the project; c) a methods section with details on how samples were collected and processed to produce barcodes; d) a conclusion section, where the difficulties encountered and the possible relevance of the work to science and society will be discussed.
 - Step 6: The teams will finalize the project, to create a final report and a poster to be presented in a meeting at the end of the School year.

Use of technology and multimedia

Technology and multimedia can help teachers and students to use the huge amount of information and the interactive tools available in the web, to stimulate new ideas and projects.

These technologies allows teachers and students to develop projects, receive feedback and communicate with online collaborators, including sharing the progress and process of the study. Such technologies allow the creation of communication platforms to spread students' work outside the classroom walls (Figure 5).

The screenshot shows an iPad interface with a status bar at the top displaying 'iPad', signal strength, '20:40', and '95%' battery. The main content area is divided into several sections:

- Text on the left:** "In terms of total mass, there is about 1,000 times more phytomass (photosynthetic plants, phytoplankton, and so on) on the planet than animals. Yet animals consume almost 20% of the total phytomass produced each year by nibbling, scraping, and filter-feeding through the microbial pastures of the ocean. Who owns the planet, plants or animals?"
- Illustration:** A detailed illustration of a green, fern-like plant with small yellow flowers, shown in a curved, arching position.
- Text in the middle:** "Plants paint a record of climate conditions on the face of the earth. In response to extended warming trends, plant hardiness zones move north. The Carolina perennial becomes a Maryland perennial. Readers of *Life on Earth* will understand how environmental factors like temperature and precipitation act like control handles that govern the functioning of the ecosystem and determine the regional viability of plants and animals. As the keystone species of the Earth, proprietors of an industrial civilization, we have choices to make. Education now is the key to wisdom later."
- Interactive Map 1 (Top Right):** Titled "Worldwide Photosynthetic Activity". It features a world map with a color scale from blue (low activity) to red (high activity). Below the map, it says: "Interactive Worldwide Photosynthetic Activity. Green represents peak photosynthesis. Ocean phytoplankton account for half or more of global photosynthesis."
- Interactive Map 2 (Bottom Right):** Titled "Global Temperature 1884–2010". It shows a world map with a color scale from blue (cooler) to red (warmer). Below the map, it says: "Interactive Global Temperature 1884–2010. This map compares temperature readings against five year averages. Blue is cooler than average, red is hotter."

Figure 5. An e-Book can improve information and knowledge and will help in communicating the team works and projects.

Conclusions

In this project we focused on two of the actors of the educational system: science teachers and their high school students.

The project allowed constant scientific and cultural updating of the teachers and provided new stimuli to teach in a more motivated, creative and effective way. The students participating in the activities at CusMiBio can share and transmit the acquired knowledge to peer students in their school through a combination of experiments and dialogue.

This approach should facilitate productive interactions within peers while breaking the intimidating “teacher-student” barrier. Students also have the opportunity to develop a wide range of complementary skills, such as working in a team, peer exchange abilities, communication skills, appropriate language etc .

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References

- Silverstein S.C., Dubner J., Miller J., Glied S. & Loike J.D. (2009). Teachers' participation in research programs improves their students' achievement in science. *Science*, 326 (5951), 440-442.
- Pavesi G., Siccardi A., Viale G., Grazioli C., Calciolari T., Tenchini M.L. & Plevani P. (2008). Hedhogs, humans and high-school science. *EMBO reports* 9 (3).
- Tenchini M. (2006). Linking university and school: addressing the challenges of science teaching in Italy. *Science in School*, 2, 46-48.

RESEARCH ON MOBILE LEARNING SCENARIOS IN SCIENCE EDUCATION IN EUROPE

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Abstract – The paper aims to present current research on mobile learning scenarios in science education in Europe. The quality of modern mobile learning scenarios based on learning personalisation, problem solving, Web 2.0 enhanced collaboration, and flipped class methods are compared against the quality of traditional, mostly face-to-face learning scenarios usually applied in schools at the moment. Tablet devices and web applications are the main technologies used in modern learning scenarios. Flagship EU-funded projects in the area – iTEC and CCL – are presented in the paper. Method of expert evaluation of learning scenarios based on multiple criteria decision analysis and Fuzzy methods as well as its application is presented in more detail.

Keywords: expert evaluation, learning scenarios, mobile learning, personalisation, science education, tablet devices

Introduction

Systematic review of scientific literature performed by the authors on topics “‘information technologies’ and ‘personalisation’” and “‘tablet devices’ and ‘education’” has shown that information technologies (incl. tablet devices) could have a positive impact on learning personalisation and thus on learning results, but their additive value highly depends on proper application of suitable learning scenarios (LS) in general, and learning activities (LA) particularly.

Learning Personalisation

According to numerous scientific research results, personalised learning approach is much more effective in comparison with traditional “one size fits all” approach usually applied at schools currently.

Vasilleva (2008) thinks that we are teaching a new generation of students who have been cradled in technologies, communication, and an abundance of information. As a result, the design of learning technologies needs to focus on supporting social learning in context. Instead of designing technologies that “teach” the learner, the new social learning technologies will perform three main roles: 1) support the learner in finding the right content (right for the context, particular learner, specific purpose of the learner, and pedagogically), 2) support learners to connect with the right people (right for the context, learner, purpose, educational goal, etc.), and 3) motivate / incentivize people to learn.

According to Graf et al. (2006), to provide personalisation and adaptivity in technology enhanced learning systems, the needs of learners have to be known by the system first.

Lazarinis et al. (2011) consider that personalisation is based on the characteristics of the individual learners, and learner profiles can be elicited and presented to educators to help them understand their learners.

According to Chang and Chen (2011), recent advances in Information and Communication Technologies, especially web technology, mean not only that e-learning is unlimited in location of computers, but also that learners can study in the virtual learning environment. This situation may present some problems, such as social skills, personalisation / individualisation, self-regulated learning skills and communication problem.

Chen et al. (2012) consider that to provide users with more suitable and personalised service, personalisation is widely used in various fields. Chen et al. (2012) defined the concept and characteristic of the personalised learning service, and proposed a semantic learning service personalised framework.

Wang and Huang (2013) think that there has been a growing awareness that courseware should automatically adjust to the profiles of individual learners.

Learning Scenarios and Learning Activities

The term of “learning scenario” (also known as “Unit of Learning”) is referred here as an aggregation of learning activities that take place in particular virtual learning environments (VLE) using particular learning objects (LO). This notion is based on IMS LD (2003) and Koper and Tattersall (2005). According to Koper and Tattersall (2005), a “Unit of Learning” refers to a complete, self-contained unit of education or training, such as a course, a module, a lesson, etc. IMS LD (2003) conceptual vocabulary clarifies that a ‘unit of learning’ is an abstract term used to refer to any delimited piece of education or training. It is noted that a ‘unit of learning’ represents more than just a collection of ordered resources to learn, it includes a variety of prescribed activities (problem solving activities, search activities, discussion activities, peer assessment activities, etc.), assessments, services and support facilities provided by teachers, trainers and other staff members.

A learning design as an integral part of any unit of learning is a description of a method enabling learners to attain certain learning objectives by performing certain learning activities (LA) in a certain order in the context of a certain learning environment. According to IMS LD (2003), learning activities are one of the core structural elements of the ‘learning workflow’ model for learning design. They form the link between the roles and the LOs and services in the learning environment. The activities describe a role they have to undertake within a specified environment composed of LOs and services.

Activities take place in a so-called “environment”, which is a structured collection of LOs, services, and sub-environments. LO is referred here as any digital resource that can be reused to support learning (Wiley, 2000). VLE is referred here as a single piece of software, accessed via standard Web browser, which provides an integrated online learning environment (Kurilovas and Dagiene, 2010). Therefore, we can conclude that LS could consist of learning activities, learning objects and learning environment referred here as services package.

Thus, we can divide LS into three components, namely LA, LOs and VLE.

Currently, LS and LA on science education are deeply analysed, applied, and evaluated in EU flagship projects iTEC and CCL.

Related projects

iTEC (Innovative Technologies for Engaging Classrooms) is a major EU-funded project in which European Schoolnet is working with education ministries, technology providers and research organisations to bring about transformation in learning and teaching through the strategic application of learning technology. With 27 project partners, including 15 Ministries of Education, and funding of € 9.45 million from the European Commission's FP7 programme, iTEC is the largest and most strategic project that has the potential to be a flagship project for the design of the future classroom. The project brings together teachers, policymakers, pedagogical experts – representatives from each stage of the educational processes – to introduce innovative teaching practices. Future classroom's LA and LS created in iTEC are piloted and validated in over 1,000 classrooms all over Europe. In iTEC, the main attention is paid to science (i.e. Biology, Physics, and Chemistry) LA and LS.

The Creative Classrooms Lab (CCL) project is developing innovative teaching and learning scenarios involving the use of tablets in and out of school. It will validate these in policy experimentations involving 9 Ministries of Education in Europe and 45 classes that are already making use of tablets from different suppliers. Ministries of Education will also seek to co-design action research pilots with industry partners that will be project Associate Partners. CCL is one of the means to help European Ministries of Education to make proper decisions concerning large scale investments in tablet devices and related teacher training. In CCL, the main attention is also paid to science LA and LS.

The authors of the paper are Lithuanian project manager and technological co-ordinator in iTEC as well as Lithuanian project manager and lead teacher in CCL.

CCL mobile learning activities and scenarios for science education

The main steps of LS suggested by iTEC experts are “dream”, “explore”, “map”, “may”, “ask”, “re-make”, and “show”. In CCL, we use this taxonomy to create modern mobile LS based on learning personalisation, problem solving, collaboration, and flipped class methods. The authors have prepared a typical problem solving scenario based on personalised learning approach using Web 2.0 collaboration (group work) and flipped class methods for piloting in Lithuanian CCL schools.

Problem solving scenario should be implemented by the following steps: (1) Discussing the problem scenario in the groups, which promotes communication skills and cooperative learning; (2) Brainstorming ideas to cross the learning boundaries, which promotes creative learning and knowledge integration; (3) Identifying the learning issues for research, which promotes active learning and critical thinking; (4) Research to construct the action plans, which promotes new knowledge development; and (5) Reporting the research findings to the groups, which promotes peer-to-peer learning to complete the final products.

Personalised learning approach is implemented here by division of learners into distinct groups according to their level of knowledge and learning styles. We use learning styles (or preferences) grouping method applied earlier for evaluating LS quality by Kurilovas and Zilinskiene (2012), namely, Activist, Theorist; Pragmatist and Reflector: (1) Activists learn by doing; their preferred activities are: brainstorming, problem solving, group discussion, puzzles, competitions, and role-play; (2) Reflectors learn by observing and thinking about what happened; their preferred activities are: paired discussions, self analysis questionnaires, personality questionnaires, time out, observing activities, feedback from others,

coaching, and interviews; (3) Pragmatists need to be able to see how to put the learning into practice in the real world; their preferred activities are: time to think about how to apply learning in reality, case studies, problem solving, and discussion; (4) Theorists like to understand the theory behind the actions; their preferred activities are: models, statistics, stories, quotes, background information, and applying theories. There are different methods to determine students' learning styles, e.g. questionnaires, learners' interviews, analysis of their e-portfolios, data mining etc. In personalised LS, learners should be divided into distinct groups according to their learning styles before or just after Discussion stage of the problem solving activity.

Learners could be divided into groups according to their learning styles e.g. applying Web 2.0 tools such as TeamUp grouping tool created in iTEC. Collaboration in groups could be based on face-to-face collaboration and Web 2.0 tools. Groups' internal collaboration activities could be applied in Brainstorming, Identifying the research issues, and Research steps, and could be combined with the other groups in Discussion and Reporting steps of the problem solving LS.

The flipped class is a pedagogical model in which the typical lecture and homework elements of a course are reversed. Short video lectures are viewed by students at home before the class session, while in-class time is devoted to exercises, projects, or discussions. The value of a flipped class is in the repurposing of class time into a workshop where students can inquire about lecture content, test their skills in applying knowledge, and interact with one another in hands-on activities. During class sessions, instructors function as coaches or advisors, encouraging students in individual inquiry and collaborative effort. Flipped class activities could be applied in Brainstorming, Identifying the research issues, and Research steps of the problem solving LS.

Methodology

Learning activity quality criteria

As it was mentioned above, typical LS could consist of learning objects, learning activities, and learning environment(s). In this paper, we pay special attention to LA since our aim is to analyse LS independently of its learning resources and environment(s) used to implement the given LA. In this research, different LA use the same learning goals and

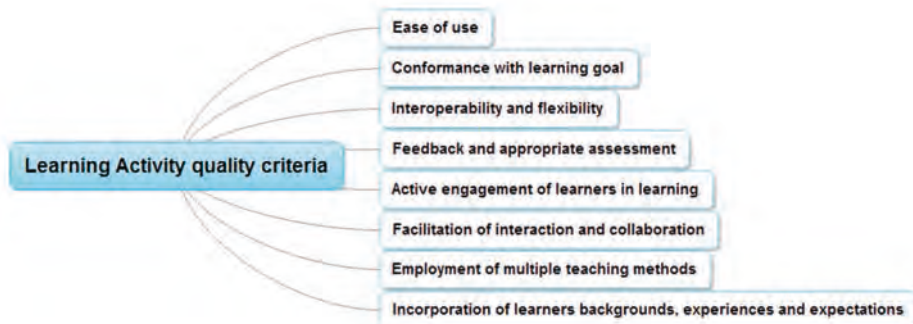


Figure 1. Learning activity quality criteria.

topics of science education. LA quality criteria were elaborated earlier in iTEC by Kurilovas and Zilinskiene (2012) (see figure 1).

Multiple criteria decision making methods

In CCL, bottom-up (i.e. users centred) LA evaluation approach based on teachers and students questionnaires will be applied after piloting scenarios in schools in autumn and winter 2013.

In the paper, the authors apply the other, so-called top-down (i.e. expert evaluation) approach. According to the top-down approach, LA should be evaluated against a number of the quality criteria by experts-evaluators. These criteria are often conflicting. Some LA could be of excellent quality against the particular criteria, and poor – against the other ones, and vice versa. Therefore, evaluation of the LA quality is a typical case where Multiple Criteria Decision Making (MCDM) methods should be applied. The results of this top-down evaluation will be compared later with the results of bottom-up evaluation implemented in CCL. LA multiple criteria evaluation method used by the authors is referred here as the experts' additive utility function represented by formula (1) including LA evaluation criteria, their ratings (values) and weights as follows:

$$f(X) = \sum_{i=1}^m a_i f_i(X), \quad \sum_{i=1}^m a_i = 1, \quad a_i > 0 \quad (1)$$

Here $f_i(X)$ is the rating (value) of the criterion i for the each of the examined LA alternatives X , and the weights a_i are normalised according to the normalisation requirement (the sum is equal 1) in order to obtain the final results expressed in per cents. The major is the meaning of the utility function (1) the better is LA alternative.

According to Kurilovas and Serikoviene (2012), conversion linguistic variables “excellent”, “good”, “fair”, “poor”, and “bad” into triangular Fuzzy numbers for the ratings (values) of the evaluation criteria should be as follows: excellent – 0.850; good – 0.675; fair – 0.500; poor – 0.325; bad – 0.150. In the paper, the evaluators (i.e. the authors of the paper) consider all criteria equally important, and all the weights according to normalisation requirement should be equal 0.125.

Results and discussion

Let us evaluate each of two LA alternatives (i.e. modern mobile – LA₁ – and traditional learning – LA₂ – activities) according to each of the quality criteria presented in figure 1 using triangular Fuzzy numbers presented earlier in the Methodology section. The following evaluation results were obtained by using applying formula (1):

$$LA_1: 0.125 \times (0.675 + 0.850 + 0.850 + 0.850 + 0.850 + 0.850 + 0.850 + 0.850) = 0.828 \quad (2)$$

$$LA_2: 0.125 \times (0.850 + 0.850 + 0.500 + 0.500 + 0.325 + 0.325 + 0.500 + 0.150) = 0.500 \quad (3)$$

The evaluation results are based on the authors' assumption that both LA alternatives are applied properly. Evaluators consider that, in general case, traditional LA₂ is easier to use than modern LA₁, and both LA equally conform to the learning goal. According to

the other quality criteria (see figure 1), LA₁ is better than LA₂. It is obvious that modern mobile LA₁ is more flexible than traditional LA₂, it has more possibilities for feedback, it more actively engages students in learning, it facilitates interaction and collaboration, it employs multiple teaching methods (problem solving, personalisation, collaboration, flipped class), and incorporates learners' backgrounds, experiences and expectations by applying students' grouping according to their learning styles. These results mean that LA₁ is almost 33% better than LA₂ (82.8% Vs 50.0%). Therefore, the quality of LA₁ is near "excellent", and the quality of LA₂ is "fair".

According to learning styles description and presentation of modern mobile LA₁ in Introduction section, it is evident that modern mobile LA are extremely useful for Activists and Pragmatists, they are also useful for Reflectors, and they have only minor additive value to Theorists. Since Activists learn by doing and their preferred activities are brainstorming, problem solving, group discussion, puzzles, competitions, and role-play, mobile learning activities based on problem solving, personalisation, collaboration, and flipped class should be very valuable for them. The same is true for Pragmatists since they need to be able to see how to put the learning into practice in the real world. Modern mobile LA are less valuable for Reflectors since their preferred activities are paired discussions, self analysis questionnaires, personality questionnaires, time out, observing activities, feedback from others, coaching, and interviews. Since Theorists like to understand the theory behind the actions, modern mobile LA are not very valuable for them.

Conclusions

Research results have shown that modern mobile learning activities based on problem solving, personalisation, collaboration, and flipped class are more flexible than traditional ones, they have more possibilities for feedback, more actively engage students in learning, facilitate interaction and collaboration, employ multiple teaching methods, and incorporate learners' backgrounds, experiences and expectations.

Research results also show that such kind of mobile learning activities using tablet devices could have a noticeable additive value for Activists and Pragmatists, and they could be also useful for Reflectors, but they have only minor additive value for Theorists.

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References

- Chang C.S. & Chen T.S. 2011. Ubiquitous Learning Grid: self-building knowledge in cross-boundary virtual learning communities. *International Journal of Ad Hoc and Ubiquitous Computing*, 8 (3), 189-201.
- Chen Y.B., Wu C.L., Guo X.J. & Wu J.Y. (2012). Semantic Learning Service Personalized. *International Journal of Computational Intelligence Systems*, 5 (1), 163-172.
- Graf S., Lin T.Y., Jeffrey L. & Kinshuk (2006). An exploratory study of the relationship between learning styles and cognitive traits. *Lecture Notes in Computer Science*, 4227, 470-475.
- Koper E.J.R. & Tattersall C. (2005). *Learning Design: A handbook on Modelling and delivering Networked Education and Training*. Springer, Heidelberg.
- Kurilovas E. & Dagiene V. (2010). *Evaluation of Quality of the Learning Software. Basics, Concepts, Methods. Monograph*. LAP LAMBERT Academic Publishing, Saarbrücken, Germany.
- Kurilovas E. & Serikoviene S. (2012). New TFN Based Method for Evaluating Quality and Reusability of Learning Objects. *International Journal of Engineering Education*, 28 (6), 1288-1293.
- Kurilovas E. & Zilinskiene I. (2012). Evaluation of Quality of Personalised Learning Scenarios: An Improved MCEQLS AHP Method. *International Journal of Engineering Education*, 28 (6), 1309-1315.
- Lazarinis F., Green S. & Pearson E. (2011). Multi-criteria adaptation in a personalized multimedia testing tool based on semantic technologies. *Interactive Learning Environments*, 19 (3), 267-283.
- Vassileva J. (2008). Toward Social Learning Environments. *IEEE Transactions on Learning Technologies*, 1 (4), 199-214.
- Wang H.C. & Huang T.H. (2013). Personalized e-learning environment for bioinformatics. *Interactive Learning Environments*, 21 (1), 18-38.

Web references

- IMS LD (Learning Design) Information Model. Version 1.0 Final Specification. 2003. Available at: <http://www.imsglobal.org/learningdesign/>, Accessed: August 13, 2013.
- iTEC (Innovative Technologies for an Engaging Classroom): EU 7FP project website. Available at: <http://itec.eun.org/web/guest/>, Accessed: August 13, 2013.
- EUN (European Schoolnet): Network's of 30 European Ministries of Education website, <http://www.eun.org/>, Accessed: August 13, 2013.
- CCL (Creative Classrooms Lab): EU LLP project website, <http://creative.eun.org/>, Accessed 13 August 2013.
- Wiley D.A. 2000. Connecting Learning Objects to Instructional design Theory: a definition, a Metaphor, and a Taxonomy. Utah State University, <http://www.reusability.org/read/>, Accessed 13 August 2013.

TEACHING EARTH SCIENCE: A WEBSITE FOR TEACHERS

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Abstract – Over the last two decades, the development of virtual tools for teaching science in school has increased dramatically (Doherty, 1996), but the majority is in English. Therefore, it is not well known, nor used regularly by Italian teachers. The purpose of this research is: 1) to evaluate Earth science teachers' attitudes towards digital tools; 2) to understand the need for appropriate digital tools for science teachers in Italian; 3) to select the main topics it should deal with; 4) to build it; 5) to test it on in-service teachers. The aim of the project is to develop a web site to host a repository of the most interesting and useful Earth science tools currently available, adapted for Italian schools. This will provide effective support to Italian science teachers without a geological background. The first part of the project has been carried on using a questionnaire sent to a selected sample. Analysis of the data indicated which topics were of most importance and a pilot session has been developed in order to test it and analyse its effectiveness.

Keywords: engaging, Earth Science, Italian teachers, website

Introduction

Even if Earth science is a discipline absolutely essential for the development of the society, unfortunately this seems not to be the perception of more and therefore the teaching of this subject at school is often overshadowed by chemistry and biology. The results of such an attitude is directly seen in the small numbers of students enrolled in Earth science university courses: for example Italian students enrolled in Geological Sciences degree courses during the academic year 2008/2009 were only 1073 of a total of 312104 newcomers (www.anagrafe.miur.it). Moreover the results achieved by the Italian students in OCSE-PISA science texts in 2006 and 2009 show, especially in the context of Earth sciences, scores well below the OCSE average (<http://www.invalsi.it/>).

The little sympathy for the Earth sciences observed in the Italian schools and universities is revealed in the superficial conduct of the complex environmental issues that characterize our country. Many of the environmental disasters that constantly hit Italy are partly the result of a lack of basic scientific culture, more precisely a lack of geological and environmental education, because, as says Ramsden (1998) «the widely held perception of science being difficult and not relevant to the lives of most people».

It should be remembered that «science is a socio-cultural activity [...]. Any nation's schools have a duty to develop scientific literacy among its pupils so that they can participate in democratic debate on scientific matters of significance. Citizens also need the skills to discuss the nature and purpose of science, skills that can be developed in school» (Trend, 2009). This is true for all the sciences taught at school, but it seems to be even more important for the Earth sciences, because «geosciences helps to create a planetary perspective» (Dal Ré Carneiro, 2004).

Methodology

On the basis of this premise we can affirm that «Earth science educators have the great responsibility to transform geoscience education into a process that must go beyond mere teaching and learning the facts, laws and theories; it must involve understanding the nature of geoscience and its relationships with society» (Bezzi, 1999). For doing that is needed to contextualize the Earth sciences to make them as concrete and fascinating as possible. Moreover this speech is even more crucial in relation to the new Italian educational reform which shifted the teaching of Earth science to the firsts years of high school, when the students are at the beginning of their higher education.

Literacy shows as «field activities are essential to geological teaching because they play a basic role at the different school levels» (Compiani and Carneiro, 1993), and that «the readily accessible contexts for learning Earth sciences may introduce young adolescents to features of scientific reasoning such as observing, hypothesizing, and drawing conclusions from evidence» (Orion, 2006). But if we analyse the present Italian situation we notice that this teaching approach is not the most common one, for example we know that «most of the Italian student are interested into laboratory activities, but they enter in the labs rarely» (Berlinguer, 2008). At the same time if we analyse the international “web-landscape” about Earth sciences teaching tools is quite clear that there are numerous interesting publications, events and sites that deal with the teaching of Earth sciences at school. Thus the questions are: how much these web materials are really exploited? What could be done for engage more teachers in their use? Would teachers like to have more materials for teaching Earth science at school? Which kind of material they would prefer? Would this materials really help the teaching, and the learning, process?

In fact it must be clarified that existing teaching materials are extremely important, but for being efficient they should be carefully selected according to the real students needs, than they have to be deeply understood and widely discussed by the teachers with their pupils.

For the reasons explained above, this project tried first to understand how much the new teaching web tools are really utilized by Italian Earth science teachers at secondary schools. Thus the first step of the project consisted on the development of a questionnaire for investigating the effective use of educational multimedia and hands-on activities in the Earth sciences teaching at the Italian high schools. Moreover the purpose of the questionnaire was also to select the Earth sciences topics of greater interests, by crossing the ministry guidelines with individual teachers’ personal impressions.

The questionnaire is composed by a series of semi-structured questions pointed to find out Earth science teachers’ attitude during their lessons and to discover their educational needs towards Earth science teaching. Some of the questions required a yes or no answer, while others asked an answer based on a Likert scale of agreement (1: strongly disagree, 7: strongly agree).

The sample chosen for the starting analysis was the group of teachers who inscribed their school at the 2012 edition of Earth Science Olympiad. Even we are aware of the fact that it is a specific sample with peculiar features, we selected it for the following different reasons:

- it is large (close to 400 teachers)
- it is geographically various (spread over almost all Italian regions)

- it comprehends different kind of schools (not only “Lyceum”, but also technical schools)
- it is quite easily reachable
- it is supposed that these teachers are more engaged than the average into update teaching process

Results and discussion

After a month from the questionnaire submission we received back 64 questionnaires from most of the Italian regions. The analysis of this first set of data allows us to make a certain kind of considerations.

As it appears clear from the figure 1, most of the interviewed teachers normally use PC and projector for doing their lectures, much more than interactive blackboard. This mean that, right now, the projector is still he most common technological device in use by teachers during their science lessons. Moreover by the analysis of the qualitative answer regarding the motivation of such an attitude, emerged that one of the reason for the preference of the projector than the interactive blackboard (LIM) is the lack of LIM at school and the difficulties connected to the classes booking plan for using it.

Another really interesting consideration about this first set of data is the fact that a really high percentage of teachers affirm to use specific websites for teaching Earth sciences and to do hands-on activities as well during their lessons.

On the basis of the previous answer is therefore really interesting to find out what teachers said when were asked them about their need of new supplementary materials for teaching Earth sciences at school. In the figure 2 are reported the percentage of interest shown by the interviewed teachers, a Likert scale is used.

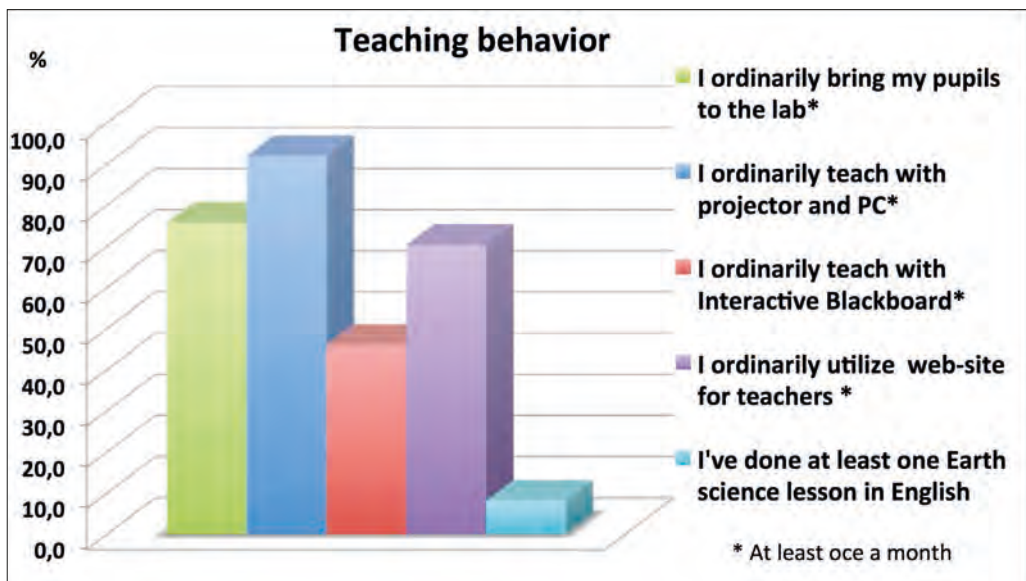


Figure 1. The percentage of teachers' behaviour.

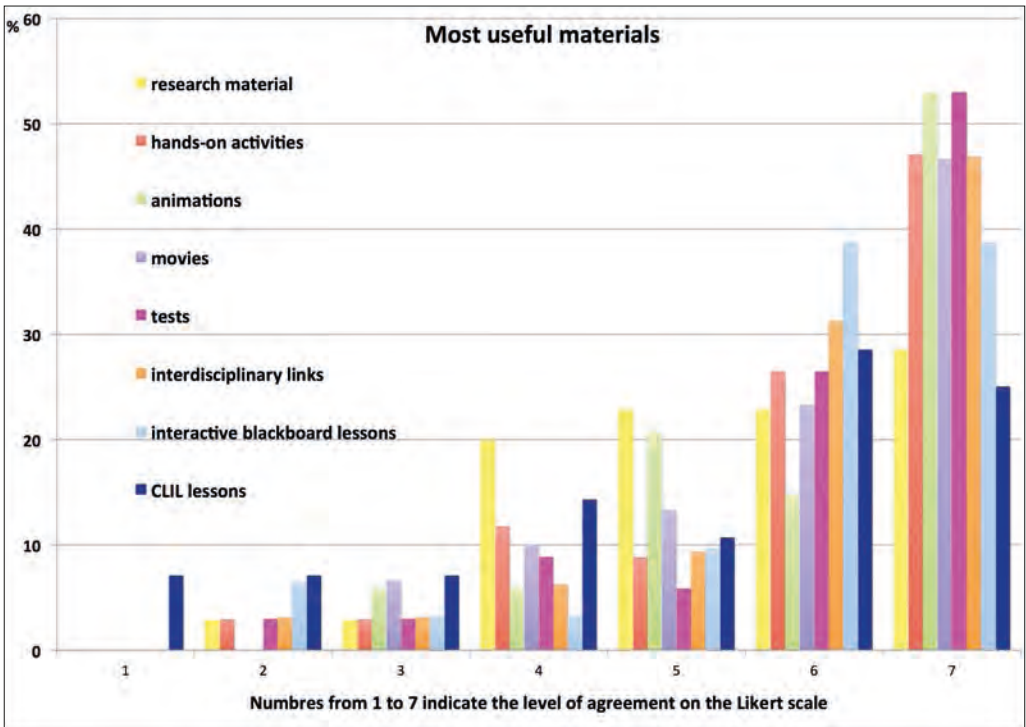


Figure 2. The percentage of the most useful learning object selected by the teachers.

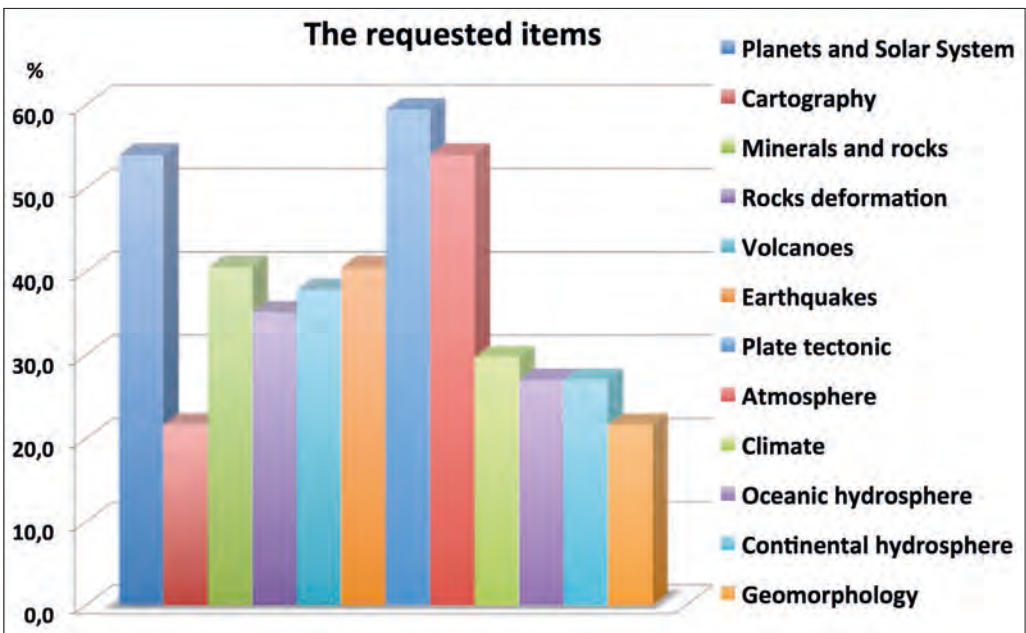


Figure 3. The items selected by the teachers.

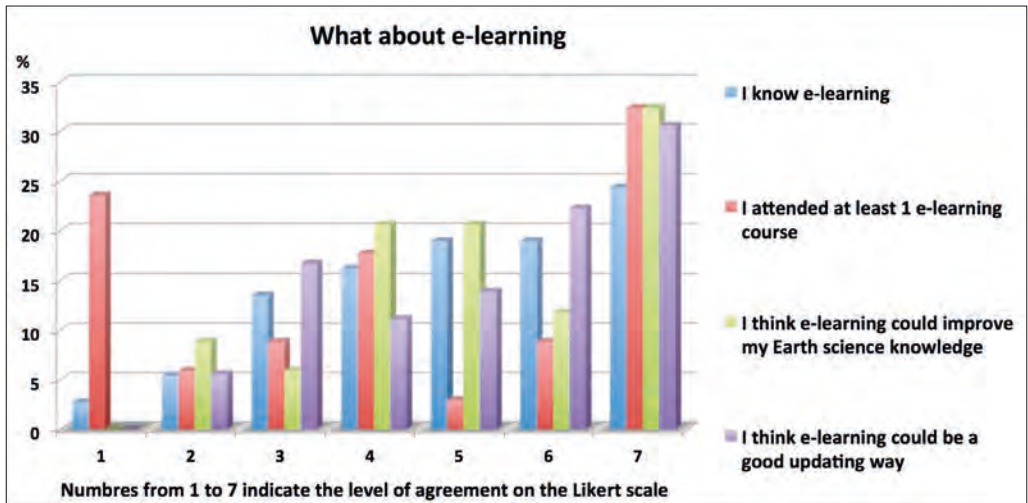


Figure 4. The level of knowledge and agreement about e-learning courses shown by the teachers.

Moreover we asked the teachers to select which items they would prefer to have more materials about (each teacher had the opportunity to choose maximum 5 different items from a set of 12). The results are reported in the figure 3.

The last question of the interview had the purpose to find out teachers' degree of knowledge about e-learning courses and their opinion about the usefulness of these kind of courses as in-service formation activities. Is clear from the figure 4 that around 1/3 of the sample affirms that e-learning courses could be an effective way to improve the teaching knowledge and to update the professional skills.

On the basis of these preliminary results we designed a website structure trying to respond to all the needs showed by the teachers and we developed new learning objects to upload. At the moment the website hosts different kind of files that undergo the Creative Common Licence, and that are free to be used and even modified by the registered teachers.

Within the selected Earth sciences topics we collected the existing web teaching material (hands-on activities, simulation, models, animations, etc.) that best fit the real teachers needs. In this regard, the selection criteria are defined as the relevance to the selected topics, the scientific validity, the ease of use, the economic and logistical needs, the link with everyday life and the relation with the territory.

Right now the first unit about the plate tectonic is complete and it is structured in different lesson, each one formed by different learning objects:

- a power point file, consisting on a key point text flanked by the most interesting pictures and images available in the web. The file is enriched by the presence of a list of web links to the most useful external materials (animation, labs, etc. ...);
- a pdf file, consisting on the transcript of the whole lesson, which is composed by the same images present in the power point lesson and by a richer text;
- a set of exercises, consisting on a group of multiple choice (from 10 to 20, depending on lesson's length) and a group of 10 open answers questions;

- a video of the whole lesson, consisting on a MP4 file lasting between 6 and 12 minutes and describing the entire content of the lesson;
- a set of specific short movies (lasting around 2 minutes) about significant key concepts, thought for explaining in a easy way the most important items of the lesson.

Presently the website is in the experimentation phase and science teachers interested in the testing have to register themselves in order to receive the log-in password and get the free access to the material. Once registered teachers can use the material as they prefer:

- the **ppt** file is free to be used directly, but can be also modified in relation to the specific teaching needs,
- the **pdf** file is a sort of a “guide” of the lesson and is thought as a support for the teachers, but could be also study material for the students,
- the **mp4** is thought as a support for the teachers, but could be used for the students as well, in the “flipped classroom” approach,
- the **exercises** are a suggestion for the teachers who would like to test the students about the content of the lessons.

The idea is that teachers can find in the lessons most of the material in the preliminary questionnaire they said were interested about.

Soon a new questionnaire will be uploaded in the website. This second questionnaire will have the purpose to understand if the proposed material fit teachers’ needs and also to find out if the website really help to make secondary school science teachers (who are not geologist) more comfortable toward Earth sciences teaching.

Conclusions

By this first part of the research emerged that teachers mostly use “traditional” digital instrument for teaching Earth sciences at school, such as laptop and projector, and that they usually utilize the web for finding useful teaching materials. Moreover emerged also that high school teachers are not completely satisfied by the materials available in the web, because they said they would like to have more specific teaching tools, like animations, movies, but laboratory protocols and research materials as well.

A website has been built in order to answer these teachers’ needs. The first didactical unit has been created according to the selected item and to the preferences showed in the preliminary questionnaire; actually the website is in a experimentation phase and it is going to be tested by in-service teachers, in order to evaluate its usefulness and efficiency. After that a new data will follow to report the results.

It must to be underlined that the chosen sample is representative of a particular kind of teachers, because the fact that they inscribed their pupils to the Natural Science Olympiad is not really representative of the average of the Italian teachers. But we assumed that the teaching needs of the selected sample can be extended also to most of others science teachers; we made the consideration that, if our motivated teachers’ sample would like to receive more material, is right to hypnotizes that also others would appreciate the same.

Another criticism of this study is certainly the fact that we received little more than the 16% of answers. Even if this result indicate that we had a feedback by one teacher each 7,

we must underline that we were not able to contact all the 400 teachers directly, but we asked to the Regional representative for the Natural Science Olympiad to submit the questionnaire to the teachers and it is possible something went wrong during this step.

References

- Bezzi A. (1999). What is this thing called geoscience? Epistemological dimensions elicited with the repertory grid and their implications for scientific literacy. *Science Education*, 83, 675-700.
- Berlinguer L. (2008). *Conferenza Stampa Laboratori scientifici. Presentazione dati e statistiche della prima ricerca censuaria e campionaria realizzata in Italia Roma, 23 Aprile 2008 – CNR.*
- Compiani M. & Carneiro C. (1993). Os papéis didáticos das excursões geológicas. *Enseñanza de las Ciencias de La Tierra*, 1,2, 90-98.
- Dal Ré Carneiro C. (2004). Dez motive para a inclusao de temas de geologia na educacao basica. *Revista Brasileira de Geociências*, 34 (4), 553-560.
- Doherty F. (1996). *Trends in Cell Biology*, 6, 160-162.
- Orion N. (2006). Learning Earth Sciences. *Science Teaching*, 23, 656.
- Ramsden J.M. (1998). Mission impossible? Can anything be done about attitudes to science? *International Journal of Science Education*, 20, 125-137.
- Trend R. (2009). Commentary: Fostering Students' Argumentation Skills in Geoscience Education. *Journal of Geoscience Education*, 57 (4), 224-232.

TEACHING SCIENTIFIC METHODOLOGY ON THE EXAMPLES OF YEAST PROTOCOLS

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Abstract – An international and national surveys demonstrate misconception among 15-years students in Poland about how yeast cause dough rising as well as fundamental shortage in knowledge of science. The renewal of teaching practice in school is needed. Among many modern educational resources available for biology teachers in Poland there are some exclusively covering these problems: 1) Examples of assessment tools for scientific literacy at the websites of Polish PISA and Centralna Komisja Egzaminacyjna website (Central Assessment Board) contain study cases of school experiments on yeast. 2) Practical protocols on yeast, originally adapted from British and Estonian resources in the Volvox project, allow students to discover the chemistry and biology of yeast fermentation in open-ended investigations. The protocols also allow students practice the scientific methodology by hands-on experiments.

It is described how the student's misconception about the role of yeast in the process of dough rising and misconceptions about reliable experiment design on yeast biology may be identified, what kind of practical protocols may be used at biology lessons to cope with these misconceptions and finally how teachers can assess the evolution of student's knowledge and understanding.

Keywords: assessment, fermentation, misconception, science methodology, yeast

Introduction

Knowledge of the nature of science (NOS) is one of the key skills for the modern and future citizens, fundamental not only for future scientists. The central elements of the nature of science knowledge are methods of investigation that include: controlled experiment with one variable, simple statistical analysis of data or replication and sample size (Allchin, 2011). These elements are very poorly represented on lesson of science subjects (biology, chemistry, physics) in Polish schools. In PISA 2006 report, when the science was the main domain, results show that Polish students have had significantly lower abilities in identifying scientific issues and using scientific evidence than in explaining phenomena scientifically (Federowicz et al., 2007; Bartnik and Ostrowska, 2007). The student's result in science test was correlated with the level of laboratory equipment available at school. Over 60% of Polish students declared that had never or almost never done any experiment at school lesson.

Since 2009 the national curriculum in biology for ISCED 2 formulates requirements due to the knowledge on scientific methodology, including: designing and conducting experiments and observations, describing conditions of the experiment, recognition of the control probe, conclusions formulation (Polish National Curriculum, 2009). Furthermore the national curriculum describes certain experiments and observations that should be done during teaching process. Among them is exploring whether carbon dioxide is produced

in the process of yeast fermentation. However the national curriculum in Poland does not cover all dimensions of reliability of science present in some other countries (for example the Nature of Science in USA or How Science Works in UK), it shifts the attention of teaching process to inquiry methods and science methodology.

To become well-informed adults and responsible citizens, students need to understand how evidence works – and where it can fail. They also need to be aware of the difficulties of obtaining reliable and valid data (Allchin, 2011). Practical experiments can provide contexts for learning some of ideas-about-science:

- measurement of quantities as a mean of making a more precise record of events and processes;
- repeating measurements and taking an average as a good method for reducing the effect of random error;
- design a simple investigation of the relationship between two variables while keeping other variables and factors constant (Millar and Osborne, 1998).

The scientific inquiry is a powerful tool for teachers to cope with students' misconceptions in science content knowledge. We present two examples of common misconceptions among Polish student, that were pointed out in the results of one of the PISA trial items (OECD PISA, 2006). The first misconception concerns yeast fermentation and the cause of dough rising. The second concerns the understanding of a classic concept of control/parallel observations differing by a single variable. We propose a set of exemplary resources to help teachers cope with those misconceptions in the classroom.

Methods

Several assessment tools and practical resources has been analyzed to search for those concerning yeast metabolism and experiment design based on yeast protocols. The identified and described examples of tools where tested in the following study methods:

- PISA trial item Bread dough: PISA 2006 standardization test on the random probe of 219 15-years old Polish students.
- CKE assessment tools: standardization test on the random representative probe of 917 15-years old Polish students.
- practical protocols from Volvox project were tried and tested in Estonia by the Science Didactics Department, University of Tartu (Pedaste and Täär, 2007) and facilitated for translations and adaptations for educational purposes in the Volvox project in 2008. The impact on Polish students was not surveyed, however the dissemination process of the Volvox project brought data (questionnaires fulfilled by 72 biology ISCEDII level teachers participated in BioCEN workshops) detecting whether Polish teachers find the resources helpful in the classroom practice.

Results and discussion

Analyzed assessment results indicates common misconceptions among Polish students concerning the reason of dough rising and basis of experiment designs. One of the PISA

2006 trial items pointed out a serious problem with recognition of the role of yeast in the process of dough rising (Question 1. see below). Only 35% of responders chose the correct answer “The dough rises because a gas, carbon dioxide, is produced”. 44% of students thought that the dough rises because of single-celled fungi reproducing in it. This result, however not supported by the main PISA survey on the population scale, disclose misconception not only in the biology of yeast knowledge but also in understanding of every-day process in the kitchen. The PISA trial item “Bread dough” is released and available for educational purpose or assessment in Polish schools.

PISA trial item: Bread dough

The short introduction to the item describing the experiment procedure, is followed by the questions given below.

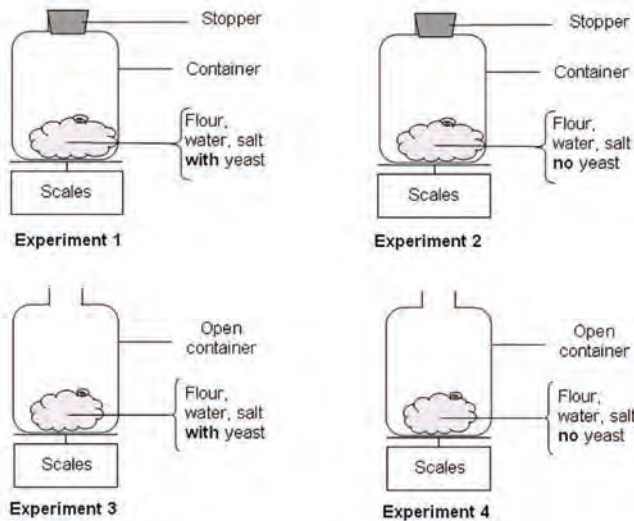
Question 1.

Fermentation causes the dough to rise. Why does the dough rise?

- A. The dough rises because alcohol is produced and turns into a gas. (11%)
- B. The dough rises because of single-celled fungi reproducing in it. (44%)
- C. The dough rises because a gas, carbon dioxide, is produced. (35%) ***
- D. The dough rises because fermentation turns water into a vapour. (8%)

Question 2.

A few hours after mixing the dough, the cook weighs the dough and observes that its mass has decreased. The mass of the dough is the same at the start of each of the four experiments shown below. Which two experiments should the cook compare to test if the yeast is the cause of the loss of mass?



- A. The cook should compare experiments 1 and 2. (28%)
- B. The cook should compare experiments 1 and 3. (35%)
- C. The cook should compare experiments 2 and 4. (8%)
- D. The cook should compare experiments 3 and 4. (28%) ***

*** indicates the correct answer.

Percentage data comes from standardization test on the probe of 219 15-years old Polish students. The percentage does not sum to 100% because of omissions and other responses.

Figure 1. Illustration to Question 2.

Examples of assessment tools by CKE

In the assessment tools for the scientific methodology it is important to give pupils the case study (Allchin, 2011), describe an experiment or to require designing of the experiment, instead of recalling the definitions and schemas. An item “Yeast experiment” was published in 2011 in a teachers’ guide-book for the new-form exam at the end of gymnasium (for 15 years old students, ISCED2) on the Central Examination Board (CKE, 2010) website. The item has complex introduction text and two questions. The introduction describes real-life experiment on yeast dough on a basis of “What do fungi eat” practical protocol (see protocol examples). The item is ascribed to the national curriculum requirements about scientific methodology in context to obligatory experiment exploring whether carbon dioxide is produced in the process of yeast fermentation.

In the first question students are asked to choose the correct hypothesis that may be tested by the described experiment, while the scientific question and the hypothesis are well defined in the introduction. Students have to distinguish between scientific question and hypothesis (distractor C chosen by 36% students). They also have to be able to recognize which variable had been tested in the experiment and choose which of the hypothesis concerns this variable (distractors A and B) which was not a problem for most students.

Question 1.

What hypothesis has Karol verified in this experiment?

- A. Sugar is not needed for dough to rise. (5%)
- B. Ingredients for rising dough are: water, flour, yeast and sugar. (9%)
- C. What amount of sugar is the optimum for dough to rise? (36%)
- D. The more sugar is added the better the dough rises. (47%) ***

The second question concerns the identification of failure in the investigation design. In the version 2a. students have to analyze the experiment design and the results to choose the correct conclusion. This question has only two distractors and probability of random answers is high so it cannot be used as valuable assessment tool. However this question is an useful teaching tool, for either starting or summarizing point of lesson about the need of repeating measurements and taking an average as a good method for reducing the effect of random error. Version 2b of the question is instead fully valuable model for classroom test or examination assessment.

Question 2a.

Students were analyzing the experiment design and the results of Karol’s experiment. Which of the following conclusions is the most accurate?

- A. On the basis of the results it is true that the more sugar is added the more dough rises. (20%)
- B. The results strongly deny that the more sugar is added the more dough rises. (39%)
- C. On the basis of only one probe it is impossible to say whether the more sugar is added the better the dough rises. (39%) ***

Question 2b.

Other students think, that Karol cannot verify his hypothesis because he failed in the experiment design. Determine if their statements are correct.

STATEMENTS	IS THAT CORRECT STATEMENT?
Karol should additionally prepare the dough without yeast and sugar.	<input type="checkbox"/> Yes / <input type="checkbox"/> No ***
Karol should place the straws filled with the dough in different temperatures.	<input type="checkbox"/> Yes / <input type="checkbox"/> No ***
Karol should repeat his experiment several times.	<input type="checkbox"/> Yes *** / <input type="checkbox"/> No

*** indicates the correct answers.

Percentage data comes from standardization test on the random probe of 917 15-years old Polish students. The percentage does not sum to 100% because of omissions and other responses.

Described examples of assessment tools (the PISA ones as well as the CKE ones) are refreshingly new for Polish examination system in science. Until now, students were never asked to focus on good practice of science investigations, its limitations or reliability of data. Those simple examples introduce new quality of science exams and shifts the balance of science subjects syllabuses and classroom practice from content knowledge only into practice about how science works.

Protocols examples to cope with identified misconceptions

Students should develop an understanding of how science works with the goal of interpreting

the reliability of scientific claims in personal and public decision making (Ziman, 1978).

The project “Volvox - Innovative network to support biology teaching in Europe” (www.biocen.edu.pl/volvox) contributed open-source proven laboratory protocols, animations and other resources to enhance biology teaching in schools across Europe (Volvox project, 2008). Resources containing instructions for easy practical experiments for classroom are the most popular resources at the Polish Volvox website. Among them are: “How to design a scientific experiment?”, “Why does dough rise”, “What do fungi eat” and “Im-mobilized yeast”.

“How to design a scientific experiment?” is a text-based activity with short experiment that shows the experimental methodology. Examples of real-life situations are described as being in the scheme of science methodology: beginning with scientific question, through the hypothesis, experiment, controls and result analysis to answer the question. Especially the need and the meaning of control probes are shown in the examples of real-life inquiries and a laboratory experiment. The protocols are the simplest introduction to the scientific methodology.

“Why does dough rise” and “What do fungi eat” are resources prepared by the Science Education Department at University of Tartu and widely used and tested in Estonia. Also Polish teachers find it helpful in the classroom practice (15% of questioned teachers pointed the fermentation protocols as the most useful in the classroom practice among 11 others protocols). Both protocols has a learning schema that introduce students to a science-related problem. Students have to formulate scientific question that is available for



Figure 2. Volvox project experiments with yeast.

investigation, formulate hypothesis and conduct experiment including the change of one variable, repeated trials, control probes, recording quantitative results, plotting a graph and drawing conclusions. “Why does dough rise” protocol contains a study of temperature as a factor influencing a life of yeast. “What do fungi eat” protocol investigates the influence of different concentration of substrate on the yeast fermentation rate. The advantages of the protocols are: a very simple laboratory design (cheap and widely available equipment) and a great potential of developing open-ended investigations.

“Immobilized yeast” protocol from UK is an introduction to quantitative study of fermentation by using yeast cells immobilized in sodium alginate. The activity of yeast is readily monitored by measuring the volume of gas (carbon dioxide) evolved during the yeast metabolism. The protocol supports not only biological education but technology as well. The immobilization techniques of biologically active components in biotechnology processes may be easily performed.

Open-ended investigations are specially needed and valuable while teaching scientific literature. The protocols described above may be developed into additional investigations on yeast biology, such as:

- alternative substrates for yeast fermentation,
- changes in fermentation rate depending on different substrates usage in yeast metabolism,
- is fermentation (anaerobic process) the only yeast metabolic reaction that produces gas,
- comparison of different type of yeast e.g. wine-makers’ or bakers’ yeast
- searching of optimum conditions for dough rising
- searching for biological and chemical factors that influence yeast fermentation in “grandmothers kitchen book”,
- does immobilization process influence the activity of yeast cells, *etc.*

Conclusions

Understanding of the nature of science should be a skill of every well educated citizen of the modern world. The key aspect of the subject is knowledge about scientific methodology. Since 2008 Polish curriculum of biology, chemistry and physics require the students to obtain the skills and knowledge of scientific inquiry. Incorporating these aspects into lessons in Polish schools requires refreshment of teaching methods, inspiration from educational resources and new methods of assessment. Presented examples of educational tools concern everyday problems and situations that are familiar to students. Making hands-on practice experiments and using scientific inquiry during the teaching process help overcoming common misconceptions. Adequate assessment tools must be developed and used at classroom and exams to complete the teaching process.

References

- Allchin D. (2011). Evaluating knowledge of the nature of (whole) science. *Science Education* 95: 518–542. doi: 10.1002/sc. 20432
- Bartnik E. & Ostrowska B. (2007). *PISA Science 2006: Implications for Science Teacher and Teaching*. (pp. 69-77). NSTA.
- Millar R. & Osborne J. (1998). *Beyond 2000: Science education for the future. The report of a seminar series funded by the Nuffield Foundation*. King's College London.
- Federowicz M. et al. (2007). *PISA Poland. Results of PISA 2006 in Poland*. Ministry of Education. Warsaw.
- Ziman, J. (1978). *Reliable knowledge*. Cambridge University Press, Cambridge, England.

Web references

- CKE, 2010. Informator o Egzaminie Gimnazjalnym od roku szkolnego 2011/2012. Warszawa. Available at: <http://www.cke.edu.pl>
- OECD PISA, 2006. PISA Released Items – Science. Available at: <http://www.oecd.org/pisa/38709385.pdf>
- Pedaste M., Täär A., 2007, Mida seened söövad. Available at: <http://www.ut.ee/volvox/>
- Polish National Curriculum, 2009. Dz.U. Nr 4, poz. 17. Ministry of Education. Warsaw.
- Volvox project, 2008. Innovative network to support biology teaching in Europe. European project funded by the European Commission's 'Science and Society' programme in years 2005-2008. Available at: <http://www.biocen.edu.pl/volvox> ; <http://www.eurovolvox.org>

CASE STUDY, RESOURCES, IDEAS AND PRACTICE TO BRING INQUIRY-BASED POLAR SCIENCES INTO ITALIAN CLASSROOMS

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Abstract – Inspired by many international Polar Research and Education experiences, our project aimed to promote innovative science education practices and methods on topics related to the Polar Regions in the Italian school. In particular, a teaching package is proposed, based on the Inquiry-based learning approach not yet widespread in Italy. The package includes complete modules, involving lesson plans and multimedia resources. In order to evaluate the educational effectiveness of the project, all the resources have been tested by a group of teachers and pupils. The testing has led to didactic characterization of each resource in order to facilitate their use in the classrooms.

Keywords: Earth Sciences, IBSE, Inquiry-based learning, polar education, Polar Sciences, teaching resources.

Introduction

Polar Regions represent one of the most interesting natural environments that can engage students on topics related to global changes. Consequently, many international polar projects have been developing educational and outreach sections (e.g. SCAR, Scientific Committee for Antarctic Research (<http://www.scar.org/communications/>), APECS Association of Polar early Career Scientists (<http://www.apecs.is>), ANDRILL Antarctic geological DRILLing (www.andrill.org), promoting enthusiasm for both formal and non-formal polar education worldwide (<http://ipy-osc.no/> and <http://www.ipy2012montreal.ca/>). Our project aims to promote Polar Regions in the Italian school, since the elementary class level. The project is addressed in Teaching Earth Sciences PhD curriculum of the School of Advanced Studies at the University of Camerino (Italy). This curriculum is composed of a group of long-experienced teachers, PhD students at the same time, who are promoting the Inquiry-based learning to geosciences in the Italian School, under the recommendation of the Rocard Report (2007). Although the Inquiry based Science Education (IBSE) is quite new in the Italian School context, Polar Sciences are a subject where this educational approach can be experimented successfully. The project started at University of Camerino in 2011 and was developed in collaboration with the University of Siena. In fact, the project benefits from active collaboration among schools, science museums and universities.

Methodology

Aims of the project

In order to introduce Italian teachers to the inquiry-based learning of geosciences, we are proposing an educational pathway based on a teaching tools package that can be easily used in the classroom. The teaching resources were inspired by real experimental data coming from the research world. In fact, they are based on the data collected in a case study related to the ANDRILL (Antarctic geological DRILLing) project that in 2006-08 recovered a couple of sediment cores from the Antarctic seafloor. The evidence coming from this research project has suggested a lot of investigable questions, that can easily engage pupils and bring them through a series of inquiring activities about polar topics and Earth Science issues more in general. For example, rocks erosion, sediments deposition, principles of stratigraphy, relative and absolute dating, water and ice behaviour are the most interesting. The teaching package consists of modules including a dozen of full lesson plans, hands-on labs and multimedia tools (e.g. smart board lessons, lab video-clip and mini video-lectures). The resources have been designed considering requests both of novice and expert teachers. Using these resources, novice IBSE teachers could feel more confident in approaching IBSE, whereas the expert teachers could find ready resources, saving time for lesson preparation. Moreover, our aim was also to produce versatile material, which can be useful not only for teachers interested in promoting polar topics, but just in improving the Inquiry Based Science Education in the classrooms. All the resources are in fact completely independent of each other, but they can be linked together in a unique educational path. In order to guide teachers during the activities, the lesson plans are available both in teacher- and student-version and they are temporarily proposed in Italian only, even if non-Italian speakers can use easily some media resources. Finally, the modules will be soon downloadable for free in a dedicated UNICAM website (www.unicam.it/geologia/unicamearth).

Case study

All the teaching activities were inspired by a case study consisting of the analysis of some characteristics of seafloor sediments in the first 200 meters of the ANDRILL MIS 1-B core. In particular, the study involves the evaluation of some parameters related to lithology, like shape, dimensions and clasts amount along the record. The whole MIS 1-B record is about 1280 m long and spans the last 13.7 millions years of Earth history (Wilson *et al.*, 2007). It has been recovered by an international research group of scientists in McMurdo Sound, Ross Embayment (Antarctica), during the austral summer 2006/07. The aim of the analysis was to detect further evidence on the behaviour of Ross Ice Shelf in the last 2.5-3 Ma, in particular the advances and retreats of ice cover, depending on past climate changes. Consequently, this kind of analysis could evidence fine oscillations of the glacial cover above the drilling site that can be argued from the morphology variation of the sediments transported by the glacier streams, depending on their global movements and their erosion power. The core portion under analysis corresponds approximately to Pleistocene period, when the glaciations occurred, consequently this kind of analysis could be useful to better understand the behaviour of the Antarctic ice cap in glacial and interglacial steps. On the other hand, the ice cover is directly connected with the global sea level and

consequently this kind of study could also gain new information about this issue, which is so fundamental to make prediction about the future Earth climate.

Lesson plans and instructional resources

The lesson plans are based on the inquiry-based 5 E's model (Bybee *et al.*, 2006) and inspired to the definition of *inquiry* given by Linn M.C. *et al.* (2004). Their structure differs from common “cookbook” activities, in which students are not autonomous in investigating, and have to follow tasks sequences and strict procedures (Magee and Flessner, 2011). Moreover, the lesson plans differ also from completely open Inquiry activities, in which many students, as well as teachers, often struggle (Bianchi and Bell, 2008). In our modules we propose continuous alternation between action and reflection, consequently the teacher has a facilitator role, guiding pupils in a typical “structured inquiry” (Bell *et al.*, 2005). Moreover, each lesson plan is linked to all the materials needed to carry on the investigation, but at the same time giving space to correct terminology, laws formalization, and basic scientific information. Anyway, students can use tools autonomously without suggestions or guide, for example in a flipped-classroom approach (Bishop and Verleger, 2013). Detailed worksheets (teacher and student worksheet) allow users to perform every activity.

Student and teacher worksheets

Each lesson plan follows a standard template, organized in sections (Figure1). The student worksheet consists of the following:

- *Master worksheet*, including a short case study, some investigable questions and the list of the activities. Moreover, it includes some blank textboxes where pupils can write down their hypothesis and opinions and suggest strategies to design experiments.
- *Documents*, collecting basic information about the topics, links to web resources as well to lab video-clips and mini video-lectures. They can be consulted whenever the pupils need.
- *My experiments* including the guide to hands-on and minds-on labs, which allow pupils to gain evidence about the initial investigable questions, but also propose several alternatives that might be tested.
- *My explanation*, allows pupils to collect and organize their data, interpreting results and explaining phenomena observed in the experiments.
- *Outcomes*, including a guided activity that makes pupils able to extend their knowledge in a more general sense, or to other general contexts. This section can be also used to assess skills and knowledge gained with the activity.

The teacher worksheet has the same organization of the student-worksheet but includes basic teaching information, like educational objectives, indication about pupils target and strategies to adopt in the classroom. Moreover, it helps teachers to guide pupils in the whole activity, suggesting how to follow them, step by step, guiding and facilitating their work at different moments. Furthermore, the teacher worksheet includes all the expected results from the hands-on laboratories, some suggestions to perform them successfully, and finally the expected correct answers to exercises.

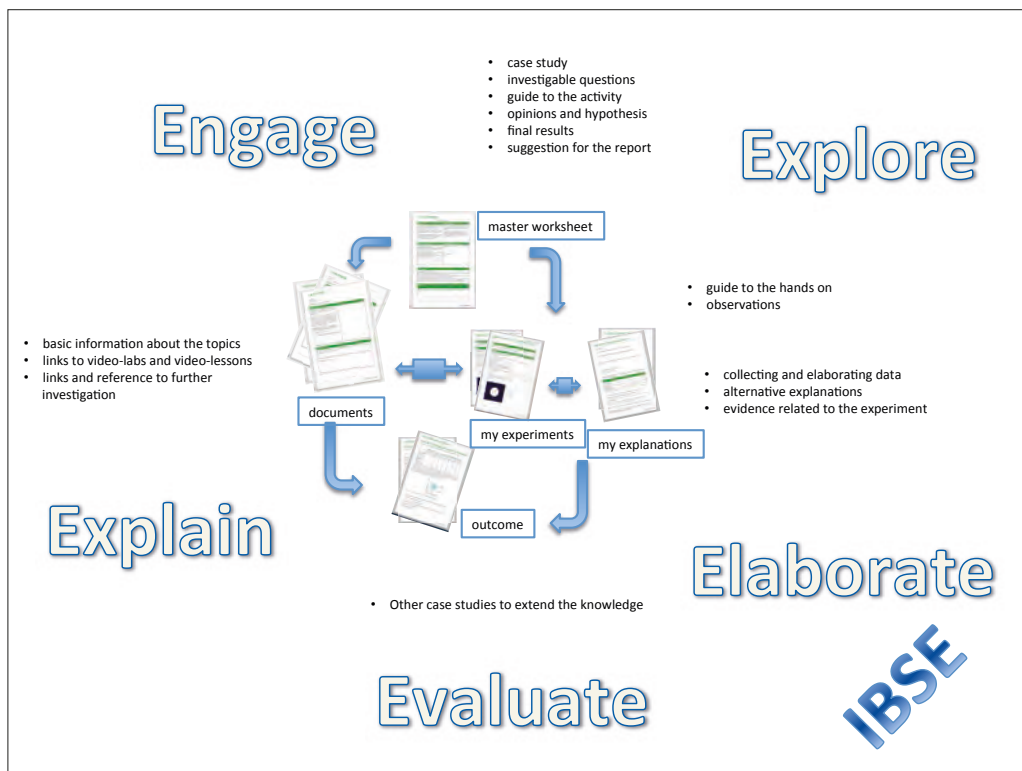


Figure 1. Structure of each lesson plan.

Media resources

The media have been designed in parallel with the lesson plans in order to be adapted to the activity demands.

The lab video-clips show the same experiments suggested in the lesson plans. They are recorded without a narrating voice, but showing questions as subtitles. In this way, the video can be stopped at every moment, to stimulate the pupils thinking skills. Versions without any subtitle are also available, which could be useful for teachers that are more expert on Inquiry or more confident in proposing open inquiry. Moreover, the “mute” video could be interesting also for non-Italian speakers. The video-clips can be used before or after the experiment, or instead of it, if there is not enough time to dedicate to hands-on performance.

The smart-board lessons resume the activity steps, including extra resources such as videos, images, schemes, which can be useful other than to engage students, also in promoting their active participation and learning, directly at the interactive white-board.

The mini video-lectures explain shortly some basic contents and can be used to present some phenomena to students or to resume the final outcomes.

In a flipped-classroom context all the previous media tools can be used to anticipate themes and problems (Bishop and Verleger, 2013).

Results

Inquiry-Based core of the project

Starting from the analysis and the elaboration of the MIS 1-B core data, a lot of interesting educational aspects arose. In particular, some big ideas originated that can be resumed in three driving questions:

1. Why are Polar Regions so important to understand Earth System behaviour?
2. What kind of clues comes from Polar Regions about the past of our planet?
3. How can we elaborate these clues to understand how our planet can change?

The basic ideas have suggested many possible inquiry-based questions and consequently the production of teaching activities and their related resources, all focused on natural processes that involve the Polar Regions, in particular Antarctica (Kaiser *et al.*, 2010). The topics of each activity and the questioning are summed up in the table (Table 1).

Table 1. Topics, tools and IBS questioning of the teaching package.

TITLE	LAB VIDEO-CLIP	HANDS-ON	SMART-BOARD LESSONS	VIDEO- LECTURES	IBS QUESTIONING
ADVENTURE TO EARTH'S POLES		✓	✓	✓	What are the characteristics of a planet that allow it to have Polar Regions?
ENERGY FROM THE SUN		✓	✓	✓	What are the factors that influence the amount of Sun energy reaching the Earth?
THE MAGIC SUBSTANCE, H ₂ O	✓	✓	✓	✓	What are the properties of water?
ICE POWER	✓	✓			What is the power of ice in modelling rocky surface of Earth?
If polar ice melts...	✓	✓	✓		In which way the behaviour of the ice sheet is linked to temperature variation? What happens if the polar ice melts at all?
The thermal "shield" of Earth	✓	✓	✓	✓	Why are the Polar Regions so frozen?
The Earth cover	✓	✓	✓		Why is global temperature rising?
Oceans in motion	✓	✓	✓		Why does ocean water move?
Clues about past climate from Antarctica	✓	✓	✓		What kind of clues about the past climate can we find in the sediments cores?
How was the Earth in the past?		✓	✓	✓	Where can we find clues about the Earth past climate?
Clues from Oxygen Isotopes			✓	✓	why do the oxygen isotopes respond to the global temperature?



Figure 2. ID card for the module “Ice power”.

Resources testing and outcomes

A group of in-service teachers of Primary and Secondary School from Prato, Italy, has tested each instructional resource with their pupils during the school year 2012-13. At the same time, they have been developing their own educational paths and lab activities, at the moment still in progress. Moreover, the testing group has been working not only in presence, but also in an e-learning platform, where the teachers have discussed problems, uploaded their material and posted comments and references. The testing consisted in a preliminary training course, with the presentation of the lesson plans. After that, teachers experimented the activities with their pupils, checking texts, improving the media efficacy and verifying also the reproducibility of the hands-on labs. The teachers firstly fulfilled a pre-survey, which gave indication about the status of teachers involved in the testing group, while at the end they answered to a post-survey testing the effectiveness of the modules. The questionnaire was compiled using the Horizon Research surveys as model (Weiss *et al.*, 2003). The activities have been tested also in the classrooms, in original or simpler versions depending on the class level. The survey elaboration allowed to characterize the modules and give each of them a sort of “identity card” that can be useful in guiding teachers in resource selecting (Figure 2).

The educational impact of the collaboration with the testing group was encouraging. In fact, both teachers and students showed enthusiasm for this new kind of approach and topics, posing questions, formulating hypothesis, exploring with their own hands-on activities, gaining evidence, explaining and elaborating their final results. Finally, the activities on polar issues made aware the students about global change, allowing them to understand how scientists are able to detect the Earth climate in the past, but especially feeling fully involved in the inquiry activity as true researchers.

Acknowledgement

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the golden opportunity to test the resources, and also fundamental advices to increase their educational efficacy.

References

- Bell R., Smetana I., Binus I. 2005. Simplifying Inquiry Instruction. *The Science Teacher* 72 (7): 30-33.
- Bianchi H., Bell R. 2008. The many levels of Inquiry. *Science and children* 46 (2): 26-29.
- Bishop L.J., Verleger M.A. 2013. *The Flipped Classroom: A Survey of the Research*.
- Bybee R.W., Taylor J.A. *et al.* 2006. *The BSCS 5E Instructional Model: Origins and Effectiveness*. Office of Science Education National Institutes of Health, BSCS.
- Kaiser B., Allen B., Zicus S. 2010. *Polar Science and Global Climate, An International Resource for Education and Outreach*, Pearson.
- Linn M.C., Davis E.A., Bell P. 2004. *Internet environments for science education*. Erlbaum, Mahwah, NJ.
- Magee P.A., Flessner R. 2011. 5 Strategies to Support All Teachers: Suggestions to Get off the Slippery Slope of “Cookbook” Science Teaching. *Science and Children* 48 (7): 34-36.
- Weiss I.R., Pasley J.D., Smith P.S., Banilower E.R., Heck D.J. 2003. *Looking Inside the Classroom: A Study of K-12 Mathematics and Science Education in the United States*, Horizon Research.
- Wilson G., Levy R., Browne G., Cody R., Dunbar N., Florindo F., Henry S., Graham I., McIntosh W., McKay R., Naish T., Ohneiser C., Powell R., Ross J., Sagnotti L., Scherer R., Sjunneskog C., Strong C.P., Taviani M., Winter D. The ANDRILL-MIS Science Team 2007. Preliminary Integrated Chronostratigraphy of the AND-1B Core, ANDRILL McMurdo Ice Shelf Project, Antarctica. *Terra Antarctica* 14 (3): 297-316.

Web references

- SCAR, Scientific Committee for Antarctic Research. Available at: <http://www.scar.org/communications/>
- APECS Association of Polar early Career Scientists. Available at: <http://www.apecs.is>
- ANDRILL Antarctic geological DRILLing, Available at: www.andrill.org
- Promoting enthusiasm for both formal and non-formal polar education worldwide Available at: <http://ipy-osc.no/> and <http://www.ipy2012montreal.ca/>
- Rocard Report. Available at: http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf
- UNICAM website. Available at: www.unicam.it/geologia/unicamearth

ELABORATION OF MODELS AS DIDACTIC PROJECT FOR TEACHING KNOWLEDGE OF THE NATURAL ENVIRONMENT IN PRIMARY EDUCATION

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Abstract – This paper presents an innovative educational project for teaching and learning of the subject of Knowledge of the Natural Environment in Primary Education. The experience was carried out from a conceptual, practical, educational and technological perspective with fourth year students of the Degree in Primary School Teaching at the University of Extremadura. The aim is encourage future teachers to develop teaching materials that can be used in the elementary classroom, and allow a better understanding of science by students, attracting the interest towards science in a practical, fun, entertaining and dynamic way. The projects had as basic materials making models that represent physical inventions and machines of our daily lives. Specifically, in the academic year 2012/2013, 115 models that can be used in the elementary classroom in the coming academic years have been developed. Each of the models is complemented by an educational project where some items are developed, such as learning objectives, skills employed, the social and historical context of the model, the construction process, the theoretical foundations and classroom activities based on different teaching strategies. The results obtained in this experience have shown that this type of educational projects are an excellent methodology for the teaching and learning of scientific concepts involved in the technology that surrounds us.

Keywords: Didactic project, Learning, Methodologies, Model, Science education, Teaching

Introduction

One of the purposes of education is to enable students to understand and generate knowledge, avoiding rote learning and promoting meaningful learning (Ausubel, 2000). Novak (Novak and Gowin, 1984; Novak, 1998) suggests that the changes that are taking place all over the world require innovations in education that focus on the nature and power of meaningful learning. It is in this new context where there is a need to review the traditional concepts of teaching and learning. In this sense, research in science education has among its purposes to improve and strengthen the learning process for enhancing the meaningful construction of knowledge in our students. There have been many investigations conducted over the years about what is the best methodology for teaching students. Consequently, teachers should make an effort to: search and integrate new methods of teaching and learning of science in the school, the assessment of student learning in science education, and the creation of new guidance intervention evidence-based in science field. On the Knowledge Society in which we are currently living, these methodologies should arouse the interest of students to make learning active, participatory, enjoyable and even fun. For example, in previous work we have highlighted the integration of ICT in different

areas of teaching, as they are key to the development of education and training in science learning. ICT enables the creation of teaching materials (Martínez *et al.*, 2012) as virtual labs, instructional videos, hyperrealists computer simulations (Martínez *et al.*, 2011), among many other teaching resources. With these teaching resources, when the students observe the simulated physical phenomena and virtually interact with the model, they themselves create their own mental structures that serve as a basis in the conceptual modelling of the phenomenon being studied.

However, it is essential to choose and consider the type of materials we are using in our teaching practice and the most favourable scenario for developing scientific knowledge, in terms of our students, school stage we target, and the content and objectives we set. Therefore, despite the great usefulness of ICTs in education, proposed by some authors as “cognitive tools” or “mindtools” (Jonassen, 2006), we must not forget other methodologies that lead the student to discover, understand and be able to represent their reality in a tangible way.

Thus, each learning activity that takes place in the classroom has a specific cognitive demand, simple or complex, for which students have or not, to a greater or lesser degree, the right skills. According to Jonassen (2000), cognitive tools adequately represent the learning process of a student, and must be carefully selected to support the type of procedure required to each cognitive task. To reach that level of cognitive competence, the learning environment used in the teaching process should provide students with educational tools, such as model building or didactic models. For Izquierdo *et al.* (1999), the modeling process can make the students make sense of the facts of their environment, a sense which must tend to be consistent with current scientific knowledge.

Sanmartí (2002) notes that the need to manipulate, observe and experiment to learn science depends in large part on what is regarded as the purpose of their learning. For example, if the aim is that students become capable of explaining the phenomena of the world around them using their own models and theories of contemporary science, the realization of practical works as those presented in this paper are needed in the teaching of science. For some authors, (Arca *et al.*, 1990), learning science involves learning to change the ways of seeing, reasoning, and speaking about the phenomena, and getting excited in relation to them, all simultaneously. In this sense, there have been some studies on action research programs in science teaching and learning (Bañas *et al.*, 2008, 2009). In this last aspect, these authors paid particular attention to planning laboratory practical classes and constructing demonstration models for those classes, which led to interdisciplinary collaboration with the school’s technology and computer science departments. The models were found to be very useful for classroom activities, as they stimulated a good working environment among the students. They worked and participated actively in the classes, doing the activities, asking questions, reflecting on what they observed, discussing, and trying to draw conclusions.

As teachers we want to offer a valid basic scientific training to interpret daily events around us, from a critical and participatory point of view. For authors such as Sanmartí (2002), teaching science from the earliest stages of education is a vital task, is a way of seeing the world and thinking about it. In this sense, this paper proposes the use of models as a method of teaching science that allows us to “see the world” and to “think about it” learning scientific content through inventions, machines and devices from our daily life.

Methodology

The overall objective of this work has been to develop educational materials that can be used in the elementary classroom, which allow a better understanding of science by students, arousing the interest towards science in a practical, fun, entertaining and dynamic way, through the development of models and educational projects. This general objective can be broken down into the following specific objectives:

- I. Create models of an object, invention, machine or technological device that helps understanding the scientific basis involved in its operation to transfer science and technology to the elementary classroom.
- II. Generate a contextualized learning through an educational project that falls within STS (Science, Technology and Society) activities.
- III. Promote meaningful learning through the stimulation of abilities and skills, the discovery and the construction of knowledge.

The experience was carried out during the 2012/13 academic year at the Faculty of Education at the University of Extremadura. The 253 pupils who participated in this study were fourth year students of the Degree in Primary School Teaching and attended the Knowledge of the Natural Environment in Primary Education course, within the knowledge area of Didactics of Experimental Sciences. On this course is taught the scientific and educational content that will enable the elementary teacher to perform their teaching in relation to the Knowledge of the Natural Environment. Among its objectives are: «To train future teachers of primary education to meet the challenges of the education system and adapt the lessons to the training needs of the stage of 6-12 years of the education system, performing its functions under the principle of collaboration and teamwork».

In order to achieve the proposed objectives of the course, we conducted an innovative educational project that encompasses scientific content from a conceptual, practical, educational and technological perspective. This is intended to foster meaningful learning of concepts, ideas and principles, placing them in real life, where they acquire their functionality. It is also committed to a STS approach, to arouse students' interest and to give value to the importance of knowledge of the natural environment through science.

The methodology is divided into the following phases:

First, an initial session was held with our students, future primary school teachers, by way of introduction on practical work in science education. The seminar gave the theoretical basis for learning to teach primary science through different learning strategies. Similarly, they were instructed for the successful completion of the educational project to be developed for their future elementary students.

Second, and in order to enhance group learning techniques, collaboration and teamwork, students were divided into 2-4 people working groups. In this introductory phase they were provided a guidance script for the development of the model and its subsequent introduction in the context of the teaching project to be carried out. Specifically, the project should contain at least the following sections:

- From a conceptual standpoint, an introduction section that captures the attention of primary students in and places the object to be modelled in a historical and social context, as well as the historical evolution of the invention itself.
- From a didactic point of view, a section of justification of the model, on where were

developed the prior knowledge students may have regarding the physical basis on which the model was based. This section should justify the inclusion of the project in Teaching Schedules. In this regard, it was agreed that the future teachers should contemplate in their schedules the development of this project, and that the time allotted within the knowledge of the natural environment subject.

- From a conceptual point of view, a section with the contents of the Knowledge of the Natural Environment subject that they would develop in their work.
- From an educational point of view, a section with both curricular and instructional objectives that were intended to achieve, as well as the basic skills that would be enhanced this activity.
- From a practical and technological standpoint, a section with the complete process for the construction of the model, in which there were developed the materials, blueprints, construction method, operating principle, or even a section of alternative or recycled materials that could be easily obtained in the child's environment to facilitate its completion in the classroom.
- From an educational point of view, a section that explains the activities that can be performed in the classroom with the model created. This section was open to activities of all kinds, that embraced generic skills, ICT, group work, cooperative and collaborative learning techniques, conceptual, procedural or attitudinal content, etc.

In the last phase, which lasted for two months of work, the students in their respective groups developed the proposed projects by an autonomous, active and participatory work. Each group planned and scheduled their work independently under the final supervision of the subject teacher, who was responsible for promoting, stimulating and encouraging learning through different interventions with the students. In this phase of creation and exhibition of the models produced, it has been fostered a more active way of learning through their own experience, harnessing the originality and creativity of our students.

Results

The developed learning experience has led to the creation of 115 models representing the physics on inventions, machines and devices of our daily lives. These models will be used in an experimental study in the next academic year. The objective is to determine the degree of learning of scientific content that elementary students reach after using them as teaching materials in the subject of Knowledge of the Natural Environment.

Each of the models has been complemented with a comprehensive educational project where it has been developed how can the teaching materials created be used in the classroom. Also, for each of the models it has been described the contents, prior knowledge, competencies, learning objectives, the socio-historical context of the model, the construction process, the theoretical foundation, the working, and classroom activities to perform based on different teaching strategies. The models are focused on different themes, to work a wide range of content of the subject studied. Among the issues discussed in the course of Knowledge of the Natural Environment, there are Alternative Energies, Energy Transformations, Simple Machines, Complex Machines, Light and Sound, Optical Instruments, Electric Circuits, Electricity and Magnetism, Forces, Motion, etc.

For qualitative validation of the work we have sought the views of the students who participated. They evaluated the usefulness of such methodologies as teaching and learning strategies in science. The next figures are some photographs of the models developed in this experience.

Conclusions

The results of this experience have shown that with the development of such educational projects, students who will be future teachers expand their knowledge and learn, in a very active way, different ways of teaching science in the elementary classroom. During the project, students had to research and bring into play their prior knowledge. Given the quality of the models made by the students, they have not only served in their personal learning, but also make an excellent teaching resource in the teaching process.

The students managed to make different models of the same invention or theme but with different materials and different operating physical principles. This can enrich the explanation of the concepts in the classroom, as it is possible to draw analogies and similarities of the mechanisms involved in each model.

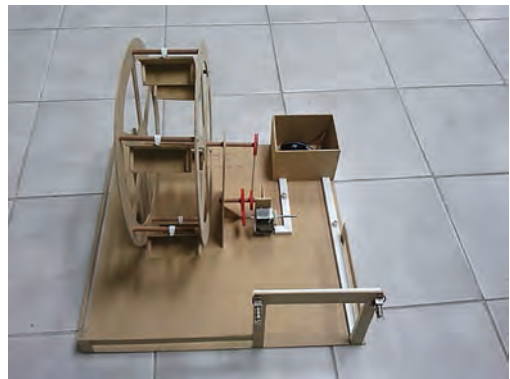


Figure 1. Some photos of the models developed. From left to right and from top to bottom: A hydraulic drawbridge, an electrical Ferris wheel, a mechanical farm with waterwheel and windmill, and a rocket.



Figure 2. Some photos of the models developed. From left to right and from top to bottom: An air-powered car, a drawbridge with pulley system, an electric solar system, a catapult, an electric car, a wind turbine and other wind turbine, and amusement rides with electrical circuits.

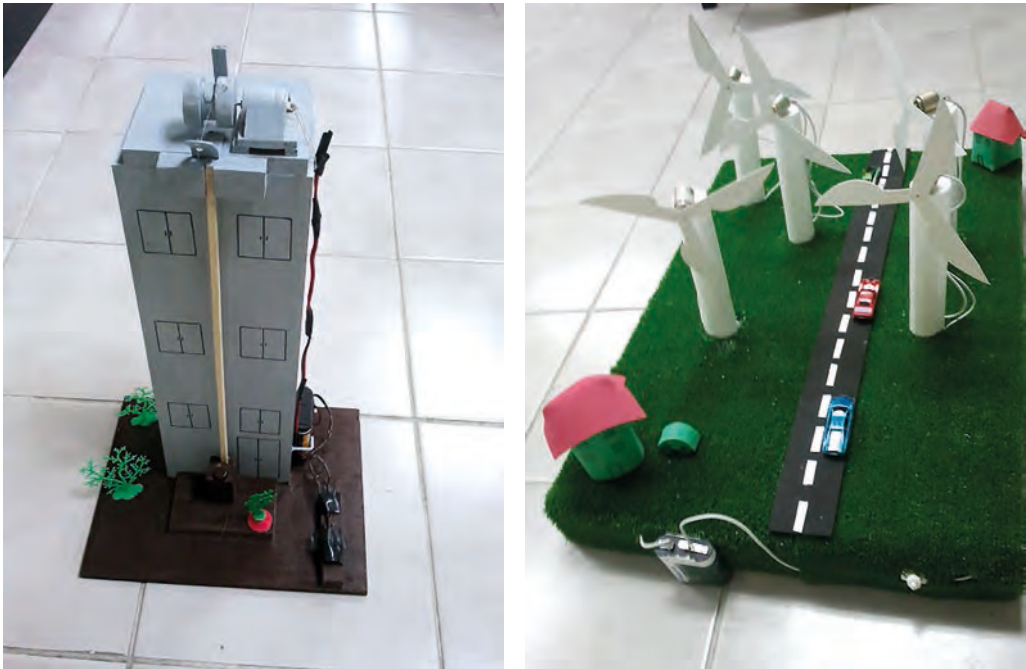


Figure 3. More photos of the models developed. From left to right: A lift and a wind farm.

Overall, the experience had a wide acceptance among students, and has served to encourage the creation of working groups. Among the opinions expressed in the various projects, students indicate that such methodologies achieve to awake in children more interest in the scientific content, as it is introduced in a novel, playful and dynamic way. Some of the reviews said the models would be a useful tool in the classroom once they have to face their own future students. The creation of the models has made much understandable and interpretable how the world around us works, and allows the child to explore, manipulate and discover the cause and effect relationships involved in each of the inventions produced. Furthermore, the project has enabled the work on historical and social aspects related to each of the models developed, which has facilitated the introduction of STS activities.

Most surveys have revealed that such projects are an excellent didactic methodology for the teaching and learning of scientific concepts involved in the operation of the technology that surrounds us, promoting meaningful learning in which theoretical content relates to procedural content.

As future perspectives for teacher intervention, it is planned to use in the next academic year the models developed in this work with 10-12 years elementary students. The different teaching units designed will be introduced, and the effectiveness of this type of teaching materials to improve science learning in students will be experimentally validated. To do so, it will be performed a quasi-experimental design with two homogeneous and equivalent working groups (control and experimental). With the experimental group we will use a didactic methodology based on the use of models, and with the control group we will use a traditional teaching methodology. The aim is to compare the amount of learning that students from the two groups are achieving and the difference of the results obtained in

terms of the teaching strategy used. We hope these materials to contribute to the meaningful learning of scientific knowledge, both conceptual and procedural. We also consider its implementation may have a positive impact on the pedagogical content knowledge of the teacher, which will allow us to continue working on this line.

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To all our 4th year students of the subject Knowledge of the Natural Environment in Primary Education, for their participation and time, as well as for the creativity and originality that they have shown in this project.

References

- Arca M., Guidoni P. & Mazzoni P. (1990). *Enseñar ciencia [Teaching Science]*. Paidós/Rosa Sensat, Barcelona.
- Ausubel D.P. (2000). *The Acquisition and Retention of Knowledge: a Cognitive View*. Kluwer Academic Publishers, Dordrecht.
- Bañas C., Díaz J.L., Mellado V. & Ruíz C. (2008). The effect of secondary education teachers' involvement in an action-research program on their students' alternative ideas on Energy. *Journal of Physics Teacher Education. Online*, 5 (1), 20-24.
- Bañas C., López A., Mellado V., Ruíz C. (2009). Metacognition and professional development of secondary education science teachers: a case study. *International Journal of Educational Research*, 3 (1/2), 129-148.
- Izquierdo M., Sanmartí N. & Espinet M. (1999). Fundamentos y diseño de las prácticas escolares de ciencias experimentales [Fundamentals and design of experimental science school practices. *Enseñanza de las Ciencias*, 16 (1), 46-61.
- Jonassen, D.H. (2000). *Computer as mindtools for schools: Engaging critical thinking*. Prentice Hall, Upper Saddle River.
- Jonassen D.H. (2006). *Modeling with technology: Mindtools for conceptual change*. Pearson-Prentice Hall, Columbus.
- Martínez G., Naranjo F.L., Pérez A.L., Suero M.I. & Pardo P.J. (2011). Comparative study of the effectiveness of some learning environments: hyper-realistic virtual simulations, traditional schematic simulations and traditional laboratory. *Physical Review Special Topics - Physics Education Research*, 7 (2), 020111.
- Martínez G., Pérez A.L., Suero M.I. & Pardo P.J. (2012). Methodologies, tools and new developments for e-learning. Rijeka. *InTech*, 169-190.
- Novak J.D. (1998). *Learning, creating and using knowledge: Concept maps as facilitative tools in schools and corporations*. Lawrence Erlbaum Associates, Mahwah.
- Novak J.D., Gowin D.B. (1984). *Learning how to learn*. Cambridge University Press, Cambridge.
- Sanmartí N. 2002. *Didáctica de las Ciencias en la educación secundaria obligatoria*. Didactics of Sciences in High School. Síntesis, Madrid.

BRIEF ITALIAN RIASEC SCALE: PRELIMINARY RESULTS

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Abstract – Professional interests are a central topic in career guidance research and practise, in particular for adolescents. One of the most important theory is proposed by Holland (1959) that identifies six kind of interests and organize them in the RIASEC (Realistic, Investigative, Artistic, Social, Enterprising, Conventional) model. To measure them, Holland (1994) developed also a complex instrument, the Self-Directed Search (SDS), extensively used also in Italy in the Poláček's (2003) version. A shorter instrument was proposed by Armstrong, Allison and Rounds (2008) but it is not yet available in Italian. The present work is aimed to fill this gap. We propose, in fact, preliminary analysis on an Italian adaptation of Armstrong and colleagues (2008) public domain scales that can be particularly useful in research projects focused on professional interests.

The instrument, translated in Italian language, was filled in by 407 students in the North-West Italy. For the analysis we use the software SPSS 20. After descriptive analysis of each item (M, SD, Asymmetry, Kurtosis), we calculated Exploratory Factor Analysis and Cronbach's alpha for each factor. Correlations among the factors and analysis of variance have been then investigated. Since a subsample of 157 filled also the SDS Poláček's (2003) version, correlation between the two instruments was finally analysed.

After the descriptive analysis, the EFA (GLS method, Oblimin rotation) evidences the six factors of the RIASEC model (51.43% Explained variance). Two items of the E type merged into the C subscale but the Cronbach's alpha estimation suggest eliminating them. The five R, I, A, S, E subscales of 8 items and the C subscale of 6 items have good internal reliability: Cronbach's alpha range between .76 and .92. Analysis of variance show significant differences between males and females and among students that attend different kind of institutes for several subscales, sustaining an ability to discriminate of the instruments. Correlations among the different subscales of the short instrument and between the Amstrong and colleagues scales and SDS instruments are coherent with previous studies.

Further analyses on a different sample will allow to confirm the structure of the Italian version of the instrument. This short scale could be an useful tool both for research works and, also, for preliminary phases of guidance projects with numerous groups of adolescents, where pithy instruments could be helping.

Keywords: Professional interests, RIASEC model, career guidance, short version scale, Italian adaptation.

Introduction

Professional interests are a central topic in career guidance research and practise, in particular for adolescents. One of the most important theory is proposed by Holland (1959) that identifies six kind of interests and organize them in the RIASEC (Realistic, Investigative, Artistic, Social, Enterprising, Conventional) model. To measure them, Holland (1994)

developed then a complex instrument, the Self-Directed Search (SDS), extensively used also in Italy in the Poláček's (2003) version. A shorter instrument was proposed by Armstrong, Allison and Rounds (2008) but it is not yet available in Italian. The present work is aimed to fill this gap. We propose, in fact, preliminary analysis on an Italian adaptation of Armstrong and colleagues (2008) public domain scales that can be particularly useful in research projects focused on professional interests.

Methodology

The instrument, translated in Italian language, was filled in by 407 students in the North-West Italy. For the analysis we use the software SPSS 20. After descriptive analysis of each item (M, SD, Asymmetry, Kurtosis), we calculated Exploratory Factor Analysis and Cronbach's alpha for each factor. Correlations among the factors and analysis of variance have been then investigated. Since a subsample of 157 filled also the SDS Poláček's (2003) version, correlations between the two instruments was finally analysed.

Results and discussion

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Conclusions

Further analyses on a different sample will allow to confirm the structure of the Italian version of the instrument. This short scale could be a useful tool both for research works and, also, for preliminary phases of guidance projects with numerous groups of adolescents, where pithy instruments could be helping.

References

- Armstrong P.I., Allison W. & Rounds J. (2008). Development and initial validation of brief public domain RIASEC marker scales. *Journal of Vocational Behavior*, 73, 287-299
- Holland J.L. (1959). A theory of vocational choice. *Journal of Counselling Psychology*, 6, 35-45.
- Holland J.L., Powell A. & Fritzsche B. (1994). *SDS professional user's guide*. Psychological Assessment Resources Inc. Odessa, FL.
- Poláček K. (2003). *Manuale dell'adattamento italiano dell' SDS Self-Directed Search* di J.L. Holland, A.B. Powell, B.A. Fritzsche. Organizzazioni Speciali, Firenze.

ACTIVE LEARNING, INICIATIVE AND AUTONOMY IN VIRTUAL ENVIRONMENTS: THE PERCEPTION OF HIGHER EDUCATION STUDENTS

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Abstract – Can virtual environments promote learning skills such that higher education students understand them? In current times, in which the profound social, economic and cultural changes further add to the development of information and communication technologies, we are faced with the need to rethink pedagogy in higher education. The focus of learning on skills and the call for flexibility, autonomy, cooperation and mobility give way to new ways of developing, evaluating and reflecting on education.

This paper examines the impact of new online educational scenarios as to how self-learning skills are perceived. The research covered 277 higher education students grouped into classrooms, and their tutoring included an online learning component. At the end of the academic semester, students responded to a range of self-learning skills adapted to learning in virtual environments. The results of the study show that virtual learning environments, anchored in a design focused on the development of skills and in a teaching model based on the principles of constructivism, autonomy and interaction can be positive in how higher education students perceive learning skills, according to the following dimensions: *Active Learning or Accepting Personal Responsibility through Learning, Learning Initiative and Guidance on Learning Experience and Autonomy*. The study examines the implications of the findings, from the perspective of both the practical intervention and the reflection on the future of educational processes.

Keywords: Education, Higher Education, Learning Skills, Perception of self-learning, Virtual Environments

Introduction

As higher education policy makers are aware that the improvement of education quality implies using Information and Communication Technologies, they have come up with reforming measures and have included in their strategic plans new operational structures and schemes, integrating solutions that involve e-learning and/or b-learning (Moreira, 2012; Monteiro and Moreira, 2012).

However, not many higher education institutions actually promote real learning alternatives in these different scenarios. We have found that these initiatives largely tend to replicate existing policies, there being cases in which new environments are used as an attraction, yet they preserve conservative educational practices. The example of course contents being transposed from paper or oral presentations to virtual learning computer environments clearly illustrates this tendency to converge and perpetuate the “traditional”. It also translates the fragmentation of knowledge, the transformation of the teacher’s role

to that of a distant tutor who often only presents the project proposal but rules out the participation in its design and development. “Platforms” are sometimes used as information repositories, offering educational materials to students and collecting tasks performed and activities completed online for greater comfort and misleading modernization. In other cases, they are viewed as competing with the teacher’s effort and dedication to students and with the preparation of classes. So we have confrontational attitudes, given the alternative of learning in a space and time different from the teaching practice. However, the role of distance learning is gradually increasing in significance.

E-learning has proven to be an opportunity for creating learning communities as it provides learning infrastructures accessible to all, irrespective of physical access. At the same time, while in e-learning, the relational nature of human cognition is preserved and the development of horizontal and cross-cutting skills is fostered in the students’ social and cooperative construction, in facilitated communications and openness in the pedagogical relationship (Anderson, 2007),

The aim of our study is to examine the impact of the new learning scenarios and of this new model on how higher education students view self-learning skills, in particular as regards self-sufficiency, accountability, self-guidance and self-regulation, confidence in their own skills, the issue of questioning, planning and decision making, the application of knowledge to practical situations, in investing and being motivated to learn, as well as exploring and deepening of learning, as reflected in improved outcomes.

The concept of learning skills under analysis is a predictive variable of the academic relation, associated to openness towards the learning opportunities, made possible by day-to-day experiences, and the ability to effectively use these formal and informal experiences. So, to engage in learning is to awaken within the self such skills as self-reliance, self-responsibility, self-confidence in pursuing goals and active participation in various social contexts, qualities that are required in all walks of life (Nyhan, 1996).

As we know, the ability to learn by oneself is now an essential requirement for school achievement. An independent student is one who can identify a need for learning and uses its personal resources effectively, using cognitive, social and creativity skills in a systematic and flexible way (Faria *et al.*, 2000).

Indeed, the ability to learn by oneself is a basic human capacity, which becomes an essential requirement for living in today’s world, self-learning becoming a way of life. However, it should be noted that learning to learn requires intention, effort, discipline and responsibility, not to be confused with simplicity, laid-back attitude or shallowness of the learning process (Lima Santos and Gomes, 2009).

Currently, the term *self-learning* appears in online learning environments often Associated to an educational philosophy of student-centred learning. In other words, the relationship between self-learning and the educational model proposed is vast and flexible, enabling various ways of conducting the process, either face-to-face or distance (Alonso *et al.*, 2005). The focus on self-learning places the student, the learning goals and contents in direct relation, and separates the student at the center of the process of the external educational agents. In the same vein, Kaufmann (2010) defines key steps to effective self-learning, from being ready to learn or become interested, including the definition of learning goals, involvement and use of resources, to the evaluation moment and participation in the learning community.

To engage in self-learning is to awaken the capacity of self-sufficiency, self-responsibility, self-confidence in the ability to achieve goals and participate actively in various contexts (Lima Santos *et al.*, 2000).

Magalhães (2011) also states that self-learning must be defined as the ability to learn in a pro-active, responsible and independent way, in the sense that the student (re)builds its own learning pathway, chooses the contents to be acquired and self-regulates the learning process (although not necessarily alone).

More than a process through which students can gain knowledge, be educated and study independently based on the available contents, self-learning can allow learners to learn in an active, independent and responsible way, learning at their own pace and development; learn at their own initiative, steering their own learning process; update and renew their knowledge and skills according to their needs; build their knowledge that will enable them to deal with future challenges, and value and complement their training (Rurato, 2008).

So, based on these assumptions, we believe it is crucial to invest in strategies that promote the sense of learning competence. The study of the sense of competence in higher education students is particularly relevant in this phase, and mostly in the early years, because young adults face various personal and external challenges that test their internal resources and the ability to deal with ambiguity and uncertainty. Being a less structured learning context and showing less constraints than other learning contexts, higher education requires students to have a greater degree of self-regulation that enhances the expression of differences in motivation and self-learning. In fact, in this period there seem to be more chances of exploring alternatives, making investments and increasing knowledge of oneself and one's abilities. The goal is, therefore, to learn to use personal resources effectively and maximize them, using cognitive, social and creativity abilities in a flexible way.

In short, our research aims to put into perspective possible and alternative learning scenarios and designs in the field of pedagogy in higher education, studying the impact of this model on the learning competence of students.

Methodology

Our study basically aims to examine the impact of virtual learning environments and of an online pedagogical model on how higher education students view learning competence. Due to the nature of the concerns, we felt that an approach such as the *Design Based Research* (DBR) was relevant, based on the *design experiments* concepts (Wang and Hanafin, 2005; Lobo da Costa and Polloni, 2011). According to Lobo da Costa and Polloni (2011), this strict and reflexive research methodology in education is better suited to test and refine innovative learning environments. Teachers assume the role of co-researchers, contributing to the development of the *design* theory in order to implement the innovations.

The methodology seeks to study educational problems in real pedagogical contexts, in order to solve relevant and practical problems, combining theory and practice through a collaborative link between researchers and professionals who seek to understand, document, interpret and improve the educational practice.

According to Reeves (2000), DBR is associated to a pragmatic epistemology that considers the theory of learning achieved collaboratively by those involved in the process. The aim of this research is to solve real problems and, at the same time, allows the construction of *design* principles that can influence future decisions.

In this sense, the empirical element of our suggested research follows a quantitative procedure arising from the outlined, quasi-experimental plan, because we included in our study 277 students from public and private, university and polytechnic institutions, already

formally included in classrooms, without randomisation. We have considered the introduction of teaching-learning models and methodologies in course units of Education and Psychology courses as being statistically analysable, the impact of which we intend to know and systematise, suggesting a set of criterion variables and examining their impact based on predictors related to student characteristics and the analysis of tasks they are faced with.

The instrument used for collecting data was the *Self-Learning Competence Scale* (Lima Santos *et al.*, 2000), with its 24 items adapted to online environments, for which the authors have granted their permission, given the relevance of self-learning studies in these “new” environments.

As mentioned, the *Self-Learning Competence Scale* – ECAA consists of 24 items, each rated on a 5-point *Likert*-like scale in which “1-Totally Disagree” indicates low competence and “5-Totally Agree” indicates high competence, showing the degree of each individual’s self-characterisation in each field of competence. The ECAA items are organised in three general dimensions: (i) *Active Learning or Accepting Personal Responsibility through Learning*; (ii) *Learning Initiative and Guidance to Experience*; and (iii) *Learning Autonomy*.

Results

Data were computer-analysed using the SPSS software (*Statistical Package for the Social Sciences* – Version 17).

As can be seen in Table 1, the ECAA showed good internal consistency with a value of .948, while the various dimensions: (i) *Active Learning or Accepting Personal Responsibility through Learning*; (ii) *Learning Initiative and Guidance to Experience*; and (iii) *Learning Autonomy*, show values of .902, .814 and .818, respectively. Assuming that an instrument with an internal consistency of .70 (Cronbach, 1984; Nunnally, 1978) can be considered fit to evaluate the variable to be measured (although, desirably, the alpha should be above .80), we believed that the instrument showed coefficients with very adequate internal consistency.

Table 1. Analysis of internal Consistency –*Cronbach’s Alpha*.

	CRONBACH’S ALPHA	NO. OF ITEMS
ECAA	0.948	24
i)	0.902	12
ii)	0.814	6
iii)	0.818	6

The correlation between the different sub-scales is also significant ($p < 0.01$), which shows the consistency of the scale in its entirety.

Table 2. Correlations between ECAA sub-scales.

	MEAN I)	MEAN II)	MEAN III)
Mean i)	1	12	
Mean ii)	.869**	1	
Mean iii)	.846**	.842**	1

In the descriptive analysis, we have highlighted the central tendency (mean) and the mean deviation as a measure of dispersion, the minimum and maximum scale value in the answers given. Table 3 shows these values for each sub-scale.

Table 3. Descriptive statistics for each ECAA dimension.

ECAA	MIN.	MAX.	MEAN	STANDARD DEVIATION
<i>i)</i>	1	5	3.9143	.53486
<i>ii)</i>	1	5	3.9110	.53791
<i>iii)</i>	1	5	3.7575	.62576

The results show that the study participants used all points on the scale, clearly expressing positive views on their learning competences, with central values very close to 4, showing a positive impact of online environments on the promotion of competences in terms of active learning, initiative or learning autonomy.

For the comparative analysis of the sub-cohort of participants as regards gender and institutional origin of the training institution, we used a non-parametric statistics using the Mann-Whitney test (Marôco, 2007). Despite the robustness of parametric tests and the size of the cohort ($N > 30$), distributions are not symmetrical or mesocurtical. On the other hand, no previous studies were found in online environments to allow us to assume that the variables under analysis would meet the requirements of normality in the population in question.

In the hypothesis tests for the differences, we found that, according to gender, the distribution of results in any of the sub-scales did not differ, and the perception of self-learning is common for both boys and girls.

However, when groups were compared on the basis of their institutional origin, on all three sub-scales, students from polytechnic institutions show more favourable means, and they differ significantly from the university participants in the study as regards all three sub-scales.

Table 4. Mann-Whitney's *U* Test on the basis of training institution.

	ECAA I)	ECAA II)	ECAA III)
University (n=137)	3.8 (0.60)	3.8 (0.58)	3.6 (0.65)
Polytechnic (n=140)	4.0 (0.44)	4.0 (0.45)	3.8 (0.57)
<i>U</i>	7757.5	7511.5	7487.5
<i>p</i>	0.006	0.002	0.001

Conclusions

As we have said (Monteiro and Moreira, 2012) the success of education in online environments depends not only on technological and social conditions, but also, and especially, on pedagogical conditions. These new environments constantly force us to rethink the roles of teachers and students and the existing relationship between them, and also require a new way of communicating, in which they share responsibility for learning (Goulão, 2012).

As the perception of learning competences is an indicator of learning efficiency, which in a way validates the pedagogical models underlying the process of pedagogical relationship, thus study shows that, in general, students experiencing online learning environments have a positive perspective of their ability to learn actively (Moreira and Ferreira, 2011).

In other words, we can say that the results of this study show that the built online environment, whose design focuses on the development of competences and on a pedagogical model – *e-moderating* – based on the principles of constructivism, autonomy and interactive had very positive effects on how students view learning competences, according to the following dimensions: *Active Learning and Accepting Personal Responsibility through Learning, Learning initiative and Guidance to Experience, and Learning Autonomy*.

Regarding the perception that boys and girls have regarding their performance in an online environment, it should be noted that in the study we did not find significant differences in any of the dimensions under consideration. These results are identical to those found in the study by Silva and Moreira (2013).

As to the differences between public and private education, we also concluded that there are significant differences in perceiving the ability to learn actively and accepting responsibility through learning, as well as in the learning initiative and guidance to experience, where private education students are at a clear vantage point.

These more favourable results for private education students may be related to the greater experience of their teacher, who are clearly more at ease in these environments, while the public education teacher is less experienced in e-learning modalities. Besides the influence of teachers, we have to take into consideration the different training culture of both types of institutions.

Given these results, we believe that there has to be a change of culture and renewal of pedagogy in higher education, using the potential offered by these online environments. Indeed, it seems to us that online education is an open window for the adoption of a new educational paradigm, focused on the student's active learning. And whether it is e-learning and/or b-learning solutions we are talking about, what matters is that we need to combine different teaching approaches, use various (technological) resources and adopt different living spaces in the teaching-learning process.

References

- Alonso F., López G., Manrique D. & Viñes J.M. (2005). An instructional model for web-based e-learning education with a blended learning process approach. *British Journal of Educational Technology*, 36 (2), 217-235.
- Anderson P. (2007). *What is web 2.0? Ideas, technologies and implications for education*. JISC, Bristol.
- Cronbach L. (1984). *Essencial of psychological testing*. Harper e Row, New York.
- Dede C. (2005). Commentary: The growing utilization of design-based research. *Contemporary Issues In Technology and Teacher Education*, 5 (3/4), 345-348.
- Faria L., Rurato P. & Lima Santos N. (2000). Papel do auto-conceito de competência cognitiva e da auto-aprendizagem em contexto sócio-laboral. *Análise Psicológica*, 2, 203-219.
- Goulão F. (2012). Ensinar e aprender em ambientes online: alterações e continuidades na (s) prática (s) docente (s). In Moreira J.A. & Monteiro A. (Orgs.). *Ensinar e aprender online com tecnologias digitais: abordagens teóricas e metodológicas*. (pp. 77-98). Porto Editora, Porto.

- Magalhães M. (2011). *Autoconceito de competência e autoaprendizagem em alunos do ensino secundário: Comparação de cursos científico-humanísticos com cursos profissionais*. Dissertação de Mestrado. Universidade Fernando Pessoa, Porto, Portugal.
- Marôco J. (2007). *Análise estatística com utilização do SPSS*. Edições Sílabo, Lisboa.
- Monteiro A. & Moreira J.A. (2012). O Blended Learning e a Integração de Sujeitos, Tecnologias, Modelos e Estratégias de Ensino-aprendizagem. In Monteiro A., Moreira J.A., Almeida A.C. & Lencastre J. (Orgs.). *Blended Learning em Contexto Educativo: Perspetivas teóricas e práticas de investigação*. (pp. 33-58). De Facto Editores, Santo Tirso.
- Moreira J.A. & Almeida A.C. (2011). Self-concept of competence of higher education students learning in virtual environments. In Mendez-Vilas A. (Ed.). *Education in a Technological World: Communicating Current and Emerging Research and Technological Efforts*. (pp. 399-405). Formatex, Badajoz.
- Moreira J.A. (2012). Novos cenários e modelos de aprendizagem construtivistas em plataformas digitais. In Monteiro, A., Moreira J.A. & Almeida A.C. (Orgs.). *Educação Online: Pedagogia e Aprendizagem em Plataformas Digitais*. (pp. 29-46). De Facto Editores, Santo Tirso.
- Nyhan B. (1996). *Desenvolver a capacidade de aprendizagem das pessoas: Perspectivas europeias sobre a competência de auto-aprendizagem e mudança tecnológica*. Eurotecnet, Caldas da Rainha.
- Nunnally J. (1978). *Psychometric theory*. McGraw-Hill, New York.
- Rurato P. (2008). *As Características dos Aprendentes na Educação a Distância – Impacto no Processo Educativo com vista ao Desenvolvimento de Estratégias de Sucesso*. Tese de Doutoramento. Universidade de Aveiro, Aveiro, Portugal.
- Silva, C. & Moreira, J.A. (2013). A promoção de competências de aprendizagem em ambientes online no ensino da matemática. *Revista Educação a Distância e Práticas Educativas Comunicacionais e Interculturais*, 13 (1), 68-86.

ADVANCED COMPUTER TECHNOLOGIES AS AN INSTRUMENT FOR STUDENT'S VIRTUAL REFLECTION DEVELOPMENT

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Abstract – Active use of social networking services by the youth creates a certain reaction among the teachers. According to some of their estimations, it is an escape from reality, the evidence of the crisis of civilization and personal degradation. Others see a virtual community as an important and valuable product of civilization opening new perspectives for a personality. There, in connection with this contradiction, the question of mental mechanisms raises ensuring the stability of personality in the changing world. The process of reflection is one of these mechanisms. This paper presents the analysis of the main features of the current state of the virtual reflection problem. The results of the investigation of high school students' common and virtual reflection are being discussed.

Research was conducted at the Kharkov school (Ukraine) among students 13-17 years old. The obtained data testify a slight exaggeration of the computer addiction problem of school children and substitution of the real environment by the virtual one. The majority of students do not consider themselves active users of social networks and are characterized by a higher rate of general rather than a virtual reflection.

However, there is a large group of schoolchildren, for which social networks are an important environment for developing their abilities for social adaptation and reflection. It was found that under certain conditions, the development of virtual reflection may be a factor of personal growth development.

Practical recommendations are given on the use of advanced computer technologies as an instrument for the virtual reflection development of school children in a virtual community.

Keywords: building virtual communities, experiences in primary and secondary education, research projects, technology in teaching and learning.

Introduction

Global society informatization, extremely rapidly changing our lives, stimulates children's interest in PC. On the one hand, an educational practice proved the use of ICT in education to be pedagogically appropriate, as it promotes the development of cognitive and creative skills of students.

On the other hand, it is proved that in many cases, the computer causes a negative impact on the child's psyche, leading to computer addiction and degradation of social relations of the individual. I.G. Korsuntsev believes such passion for the virtual reality leads to a one-sided and defective development as well as to stereotyped behavior. Besides, it is especially dangerous for children and youth consciousness (Korsuntsev, 2004).

In connection with this contradiction the question of both mental mechanisms and processes ensuring the stability of personality in the volatile world and of internal reserves,

which have not been fully disclosed in the development process is raised.

These processes, first of all, include a process of reflection, which is closely studied by psychologists, philosophers, sociologists in the last few decades.

Basing on the analysis of the literature (Vygotsky, 1956; Meshcheryakov and Zinchenko, 2003; Karpov, 2003; Rybinshteyn, 1946; Semenov and Stepanov, 1982), we found that the reflection is a form of acquisition of personal experience as well as conscious and arbitrary process of reflection and reconsideration by the person of relations with the social world. And these relations are manifested in person's communication with other people and in active assimilation of new social standards, behaviors and activities.

There are various definitions of reflection in scientific literature. So I.N. Semenov and S. Yu. Stepanov while developing reflective and humanistic direction in psychology, highlighted four types of reflection according to their functions: intellectual, personal, communicative and cooperative [6, p.15-26]. Intellectual reflection aims to reconsider and transform the initial model of object into more adequate. Personal reflection is based on self-defining of the individual and making new images of oneself. In particular, while solving non-standard, creative task the subject comes to a solution basing on this type of reflection. The function of cooperative reflection is in reconsideration and reorganization of collective activity. The function of the communicative reflection is based on the comprehension by the active subject of the way he is perceived by the partner in communication.

A.V. Karpov highlights the following types of reflections: situational, retrospective and perspective (Karpov, 2003). Situational reflection provides direct self-control of person's behavior in actual situation. Retrospective reflection is found in tendency to analyze already fulfilled in past activity and completed events. Perspective reflection correlates with the function of analysis of the coming activity or behavior.

In today's world of information and communication technologies, in the world of virtual reality qualitative changes take place in types and ways of existence of the reflection. I.G. Korsuntsev believes that reflection is increasingly becoming "artificial" (Korsuntsev, 2004).

It is expedient to define a new type of reflection of personality - a virtual reflection (Korsuntsev, 2004; Nosov, 2000; Nosov, 1994).

The problem is that the virtual reflection is characterized by the uncertainty of its conceptual status and place in the psychological, educational, information and communication concepts. The source of major difficulties in understanding the virtual reflection is in a weakly developed methodological aspects and the lack of empirical and experimental methods for studying it.

The object of our study is the activity of students in virtual environment.

The subject of the study is a virtual reflection of schoolchildren.

Purpose of the work:

1. To analyze the essence of "virtual reflection", its place in defining "general reflection".
2. To study the level of general and virtual reflection in school, their interrelation with the level of academic achievements of students.
3. To develop practical recommendations on application of advanced computer technologies as an instrument of student's virtual reflection development.

Scientific novelty of the results of the study is in:

- the development of levels, conditions of a virtual reflection of students;

- the connection of common and virtual reflection with the level of academic achievement;
- a completed questionnaire of diagnosis of a virtual reflection;
- teaching tips on application of advanced computer technologies as an instrument of students' virtual reflection development in the virtual environment.

Methodology

Investigation of the level of students' general and virtual reflection

It is suggested (Korsuntsev, 2004) that communication standardizes and averages person's reflection producing uniformed and destroying traditional moral norms and standards of behavior. Therefore, they produce a new form of person's consciousness - a virtual reflection.

Theoretical analysis on the basis of investigations (Korsuntsev, 2004; Nosov, 2000; Nosov, 1994) showed that the virtual reflection is a type of common reflection, mental activity process of reflection and reconsideration by the person of relations with the virtual world, which are shown in his/her communication with other people and active assimilation of new behaviors and activities.

We believe that in virtual reflection, like in common one as well, there can be highlighted such aspects as intellectual, personal, communicative and cooperative.

A survey was conducted to determine the effect of virtual reality on the mind of a student and the overall level of the development of a virtual reflection of students as well as the dependence of level of students' academic achievement.

The study involved 130 students of the Kharkiv school 14. The age of respondents was from 13 to 17. There were three stages of the study (2011-2012).

1. *Diagnosis of the level of general students' reflection*

To investigate the level of general reflection of schoolchildren, we used the diagnostics reflexivity method by A.V. Karpov (2003).

Students were offered a questionnaire of 27 questions, including 14 direct and 13 indirect.

After being counted the total number of students' points is interpreted in to a certain mark according to an offered scale.

The results of levels diagnostic of students' general reflection are presented in Table 1.

Table 1. Diagnosis of the level of general reflection development.

LEVELS	MARKS	QUANTITY, %
low	0-3	42.80%
middle	4-6	54.30%
high	7-10	2.90%

Thus, we can see that 97.1% of students aged 13-17 have low and middle level of reflection development. And only 2.90% of them have high level. The average mark is 3.59 out of 10.

2. *Diagnosis of virtual reflection*

To investigate the level of development of schoolchildren virtual reflection (basing on A.V. Karpov diagnostic techniques of reflexivity level) we have created an online questionnaire "Virtual diagnosis of reflexivity". The questionnaire consists of 27 statements, both direct (15) and indirect (12). For example, there are some of them:

1. I am often the initiator of the discussion topics on forums, chat, creator of the group.
2. It is important for me to be perceived in the social network in the way who I really am.
3. My status (rating, popularity) in the network is absolutely not important for me.
4. Social networking is much more honest and natural, than real life communication.

The results of diagnostic levels of students' virtual reflection are presented in Table 2.

Table 2. Diagnosis of the level of virtual reflection development.

LEVELS	MARKS	QUANTITY, %
low	0-3	66.60%
middle	4-6	33.40%
high	7-10	0%

Thus, we can see that 66.6% of students aged 13-17 have a low level of virtual reflection development, which is 20% higher than the same figure of common reflection. The middle level is 33.40% of the respondents, which is 21% lower than the same indicator of common reflection. None of the 130 respondents has high level of reflexivity in social networks. The average mark is 2.58 out of 10. Consequently, a virtual reflection of schoolchildren is less developed than the general one.

The lower, compared to the general, level of virtual reflection may indicate that most students prefer to adapt themselves in real, rather than virtual environment.

3. *Analysis of the relationship of general and virtual reflection with the level of students' academic achievement*

The theory of correlation, which determines the probabilistic (statistical) relationship rather than functional was applied to establish the relationship between the factors and indicators characterizing the level of development of virtual and general reflection.

For this purpose, we calculated the correlation coefficients of the virtual and general reflection and the level of student's academic achievements. The level of student's academic achievements was defined as the student's average point in all academic subjects per semester.

For a group of 20 students the correlation coefficient indicator is significant at 0.433 (with confidence $p < 0.05$).

The results of the diagnosis of the relationship of general and virtual reflection of students, as well as the level of student's academic achievements are presented in Table 3.

Table 3. Diagnosis of the relationship of general and virtual reflection of students.

MARKS	GENERAL REFLECTION	THE LEVEL OF STUDENT'S ACADEMIC ACHIEVEMENTS
General reflection	1	0.64
Virtual reflection	0.69	0.5

Results and discussion

According to a correlation analysis of diagnostic data of general, virtual reflection and academic achievements of students, presented in Table 4 we can conclude the following:

- the general reflection index is closely correlated with the virtual reflection index (correlation coefficient 0.69);
- the general reflection index is closely correlated with an academic success index

Table 4. Reflection marks comparison for all of students.

	all of students
General reflection	3.64
Virtual reflection	3.68

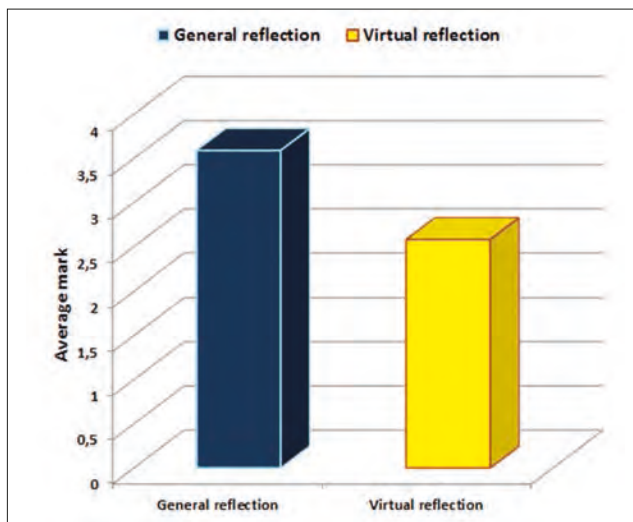


Figure 1. Reflection marks comparison for all of students.

(correlation coefficient 0.64);

Another noteworthy result of the investigation is the fact of correlations of students' reflection level with the results of their study in philological subjects, such as World Literature and Ukrainian Literature. The correlation coefficient in these subjects is the biggest - 0.56 ($p < 0.05$).

We found it interesting to study the virtual reflection of group of students who identify themselves as active users of social networks. In our study, they made 34% of the total number of respondents. Their average mark appeared to be the same as the average index of general reflection (~ 3.6) for the entire group of students.

To identify the level of the virtual reflection survey was created that took into account four of its aspects: personal, intellectual, cooperative and communicative. Analysis of responses allowed us to identify the target group of students, in which one of the aspects most clearly manifested itself. Average marks values of these aspects of the identified target groups is indicated in Table 5.

Table 5. Reflection marks comparison of target groups of students

	COOPERATIVE	COMMUNICATIVE	PERSONAL	INTELLECTUAL
General reflection	3.64	3.62	3.60	3.67
Virtual reflection	3.68	3.69	3.29	3.78

Thus, comparing the indicators of the personal, intellectual, cooperative and communicative aspects of the general and virtual reflection we see that the indicators of the communicative and cooperative aspects of virtual reflection exceed these figures of the general reflection at 0.04-0.05%. The indicator of intellectual aspect of the general reflection is

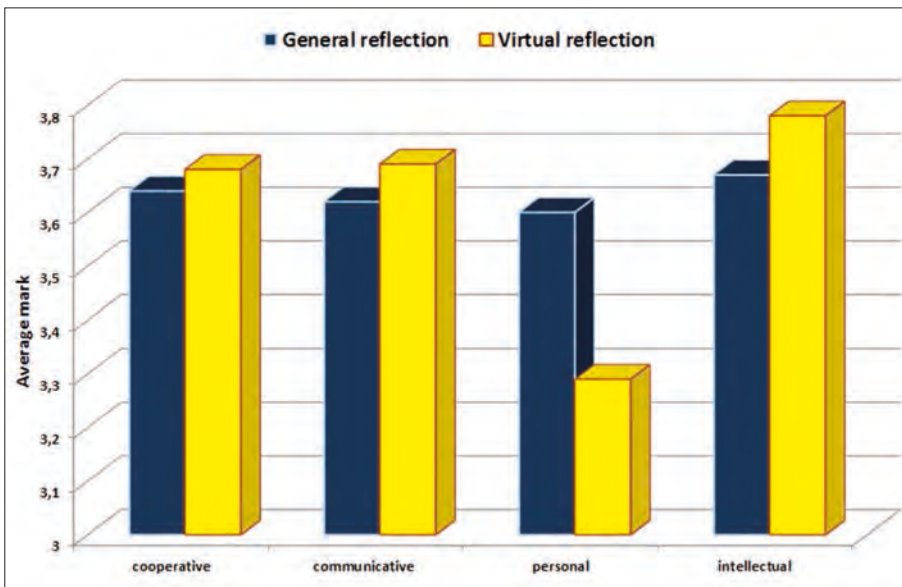


Figure 2. Reflection marks comparison of target groups of students

lower than the same indicator of virtual on 0.11.

However, the indicator of personal aspect of the general reflection is higher than the same indicator of virtual reflection at 1.01%.

It is interesting to note that the average level of academic achievements students from the target groups is something lower than the figure calculated for all students.

This may testify the fact that every third student, regardless his/her formal success in the real environment, actively uses virtual environment for simulation of various scenarios of behavior as an peculiar polygon (experimental area) for social adaptation.

So, we can say that virtual reflection development is the factor for common reflection development.

1. Assessment of conditions of virtual reflection development as the factor for general reflection development

Basin on the results of the fulfilled analysis we can name the following conditions of virtual reflection development:

- It is necessary to develop students' skills connected with personal self-consciousness: making new images of oneself in virtual environment, development of more adequate knowledge of the world.
- It is necessary to develop students' communicative skills and abilities in virtual environment, their ability to analyze and perceive oneself as a partner in communication.
- It is necessary to develop students' literary skills and ability to express his/her opinion, to analyze what was read and to synthesize new things.
- It is necessary to develop students' cooperative skills in virtual communities and groups such as reconsideration and organization of collective activity in virtual environment.
- It is necessary to develop students' intellectual skills: to emphasize, analyze and correlate personal actions with objective situation in the virtual world.

Thus, the results obtained indicate the relationship of virtual reflection with their common interrelations with students' academic achievements. Consequently, a schoolchildren's virtual reflection in virtual environment under certain conditions is a factor of student's general reflection as well as the factor of personal growth development.

Literature analysis, the results obtained as well as pedagogical practice in an educational establishment became the basis for the working out of practical recommendations on application of advanced computer technologies as an instrument of development of student's virtual reflection.

2. Recommendations on virtual reflection development

The aim of practical recommendations: virtual reflection development as well as personal, communicative, cooperative and intellectual skills of students by means of advanced computer technologies.

Analysis of the programs of studying informatics in our school allowed to highlight topical modules. It will be actual while studying them to apply computer technologies as instrument of virtual reflection development.

Among the following modules are:

- Computer networks. Internet (Form 7-11).
- Computer graphics (Form 5-11).
- Automated creation and support of web-resources (Form 10-11).
- Creation of animated images (Form 9-11).
- Processing of multimedia data (Form 10-11).
- Educational software. Interactive distant learning (Form 10-11).

Analysis of modules of informatics studying and conditions of virtual reflection development allows to define the following structure of practical recommendations:

1. Selection of means for virtual reflection development.
2. Methods of using ICT in a virtual environment.
3. Forms of using ICT in virtual environment.
4. Rules of teacher's behavior as the member of virtual community in virtual environment.

2.1. *Selection of means for virtual reflection development*

Analysis of existing pedagogical means (Kharlamov, 2000) of educational process and studying of conditions of virtual reflection development allowed us to highlight the following means of students' virtual reflection development.

- organizing and pedagogical means (academic plans, academic program of studying informatics by schoolchildren);
- visual aids (electronic textbooks on graphics editors, animation, video editors (Mogilev *et al.*, 2005));
- technical means of education and automated systems of education;
- platforms to create web-blog;
- on-line platforms to create mind maps;
- on-line platforms to create and accomplish distant courses;
- graphics processing software;
- video processing software;
- programs to create and edit animation, Flash-textbooks, educational games.

2.2 *Methods of using ICT in virtual environment*

Taking into consideration conditions of virtual reflection development as well as criteria of self-support and creativity level in students' activity, we applied the following teaching methods:

- explanatory and illustrative method;
- reproductive method;
- problem presentment method;

- heuristic method;
- researching method.

Explanatory and illustrative method of teaching is the method when students obtain knowledge from educational or methodical literature. For example, for creating esthetic graphical images or animation for social communication services by students the teacher offers electronic textbooks to be studied, explains difficulties, inoculates esthetic culture in verbal way.

Reproductive method of teaching is the method in which the application of the studied material is based on the example or rule.

Problem presentation method in teaching is the method when the teacher using various sources and means states the problem and then shows how to solve it with the help of proofs. For example, during the web-conference on the problem “Are the Internet and moral compatible?” the students become witnesses and partners of scientific research to answer the question.

Heuristic method of teaching is based on the organization of the active search to solve given cognitive tasks. According to this, the students while creating mind maps are given the topic which would develop their reflectivity. For example, the development of the collective project by the group of students “Global problems of humankind” presumes knowledge not only in informatics but also in ecology and sociology, including investigating searching. The fact that there is some interrelation of the students’ points of success in ecology with the virtual reflection index had some impact on choosing the following topic.

Researching method of teaching is based on students’ self-studying of the literature and doing certain searching after analyzing the material, setting the problem and being instructed either orally or in writing.

2.3 Forms of using ICT in virtual environment

Our experience has shown the productivity of such forms of ICT use in virtual environment at classes:

- Creation and filling-in web-blogs, live journal, notes in social communication services.
- Creation of educational, teaching applications for virtual environment.
- Communication experience with students from other countries, research associates (holding web-conferences, webinars).
- Creation and taking distant courses on various subjects.
- Creation of esthetic graphic images and animation for social communication services.
- Creation of highly cultural, moral, scientifically sound, exciting video records on actual topics.
- Creation of mind maps on actual for students’ life theme which would develop their reflectiveness.

2.4 Rules of teacher’s behavior as a member of a virtual community in a virtual

environment

Practice shows that it is expedient to present a teacher in a virtual environment communicate to students. This allows the trust and unobtrusive way to guide, correct and encourage the development of mental qualities of the identity of student.

Therefore, in order to develop a virtual reflection of students in the social networks teacher should:

- become a member of a virtual community of his/her students. This in itself provides a lot of useful information for the observant teacher. Analysis of the status, avatars, links to certain resources allows the teacher to better understand the state, the personal development orientation of the student;
- create a highly professional, highly cultural personal content, which is filled with such information about him/her in the world, which would serve as an impulse to the cultural and intellectual development of the youth;
- create culture and aesthetic sense by means of his/her own social network content;
- fill the content with multimedia elements that would reflect the historical, cultural, artistic and social achievements and values of human civilization;
- taking into account the interrelationship of reflection and practice of philology studying, to generate discussion of topical issues, particularly cultural and ethical (Ray and Coulter, 2008), to encourage students to express their own opinions;
- clearly state their own position on key issues concerning students;
- make comments, focus group's attention on certain statements of its members;
- create a positive and constructive atmosphere in a students' environment;
- share advanced technologies of effective behaviour (Swift, 2010).

Our experience has shown positive results of this approach.

Conclusions

Summarizing the results of the study, we can draw the following conclusions:

1. The analysis has been introduced of main features of the modern state of the problem of reflection. According to the sources (Vygotsky, 1956; Meshcheryakov and Zinchenko, 2003; Karpov, 2003; Rybinshteyn, 1946; Semenov and Stepanov, 1982), we found that the reflection is an arbitrary process of reflection and reconsideration by the subject of relations with the social world, which are manifested in his/her communication with other people and of active assimilation of new social standards, forms of behavior and activity.
2. On the basis of the sources (Karpov, 2003; Semenov and Stepanov, 1982) the concept of virtual reflection has been generalized. The virtual reflection is a mental process of reflection and reconsideration by the subject of relations with the virtual world, which are manifested in his/her communication with other people and in his/her active assimilation of new behaviours and activities.
3. A questionnaire "Virtual reflection diagnosis in social communication services" which

allows to determine the level of adolescents' virtual reflection has been made for school-children.

4. The level of general reflection of schoolchildren has been investigated. 97.1% of students aged 13-17 have a low and middle level of general reflection. And only 2.90% have a high level. The average mark is 3.59 out of maximum 10.
5. The level of virtual reflection of schoolchildren has been investigated. 66.6% of students aged 13-17 have a low level of virtual reflection development, which is 20% higher than the same figure of common reflection. The middle level is 33.40% of the respondents, which is 21% lower than the same indicator of common reflection. None of the 130 respondents has high level of reflexivity in social communication services. The average mark is 2.58 out of 10. Consequently, a virtual reflection of schoolchildren is less developed than the general one.
6. The lower, compared to the common, level of virtual reflection may indicate that most students prefer to adapt themselves in real, rather than virtual environment.

These results obtained testify a slight exaggeration of the computer addiction problem of school students and the substitution of a real environment by the virtual one. The majority of students aged 13-17 do not consider themselves active users of social networks and are characterized by a higher rate of general rather than a virtual reflection. However, there is a large group of students, for which social networks are an important environment for developing their abilities for social adaptation and reflection.

7. The relationship between the general and virtual reflection was established. The correlation coefficient of these two characteristics is equal to 0.69. The dependence is also evidenced by the fact that the average virtual reflection of active users of social communications services was the same as the average value of the index total reflection (~ 3.6) for this group of students.

Consequently, a virtual reflection of pupils in a virtual environment under certain conditions is a factor in the development of the schoolboy, his reflexivity.

8. Were defined the conditions for the development of virtual reflection. Among them: the need to develop personal and communicative skills of students in a virtual environment, the ability to analyze and perceive themselves as a partner in communication, writing skills of students, co-operative skills in virtual communities, groups, and the ability to play and organize collective action in a virtual environment intellectual skills students.
9. Practical recommendations on the use of advanced computer technology as a tool for the development of a virtual reflection of school students in a virtual environment were developed. The components of practical recommendations are: thematic modules, a selection of tools, training methods, uses of advanced computer technologies, as well as rules of teacher's behavior as a member of a virtual community in the services of social communications.

Our experience has shown that the introduction of advanced computer technology in the educational process – an effective tool for the development of a virtual reflection of students and, consequently, student's personal growth.

References

- Korsuntsev I. (2004). *Features of Virtual Reality*. In the World of Modern Scientific Myths. pp. 21-45.
- Vygotsky L. (1956). *Selected Psychological Studies*. pp. 519.
- Meshcheryakov, B. & Zinchenko, V. (2003). *Large Psychological Dictionary*. pp. 672.
- Karpov A. (2003). Reflexivity as a Mental Property and Method of Diagnosis. *Journal of Psychology*, 24 (5), 45-57.
- Rybinshteyn S. (1946). *Being and Consciousness*. pp. 704.
- Semenov I. & Stepanov S. (1982). *Types and Functions of Reflection in Scientific Thinking: Problems of Reflection in Scientific Knowledge*. pp. 76.
- Nosov N. (2000). Virtual Psychology. *Proceedings of the Laboratory Virtualistics*, 6, 432.
- Nosov N. (1994). Reflexivity and Virtuality. Reflexive Processes. *Proceedings of International Symposium*.
- Kharlamov I. (2000). *Education*. pp. 520.
- Mogilev A., Pak M., Henner E. (2005). *Workshop on Computer Science*. pp. 608.
- Ray B., Coulter G. (2008). Reflective Practices Among Language Arts Teachers: The Use of Weblogs. *Contemporary Issues in Technology and Teacher Education*, 8 (1), 6-26.
- Swift J. (2010). *Where Did Time Fly*. pp. 149.
- Mukii T., Filenko I. (2011). Features of Formations Processes of Young at the Persons of Youth Age During Teaching in Higher Educational Establishment. *Visnik Harkivskogo Natsionalnogo pedagogichnogo universitetu im. G.S. Skovorody. Psychology*, 41, 116-128.

PARTICULAR QUALITIES OF DEVELOPMENT OF SCHOOL STUDENTS' REFLECTIVE ABILITIES

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Abstract – Many researchers note the leading role of a reflection in effective, harmonious self-realization of the personality, in formation of professional abilities, in ensuring development and self-development. In the concept of developing training the reflection is considered as an essential indicator of high intellectual development. However this psychological phenomenon and its role in formation of an independent position of the school student in educational activity at a stage of a professional self-determination are many-sided and insufficiently studied. This paper presents an analysis of the main features of the development of reflective abilities of schoolchildren aged 14-18 years.

In the course of this research levels, conditions and features of development of reflective abilities of school students in profile training were defined. Practical recommendations on the use of advanced psychological, educational and computer technologies as an instrument of development of reflective abilities of school students were also developed.

Keywords: ICT, personality development, professional self-determination, psychological and educational technologies, reflective abilities, training process

Introduction

Presently one of the most priority problems of school education is preparation of school students for life in the conditions of the dynamic, changeable real world. Before our eyes there is a formation of a new paradigm of education which is caused by increase in volumes of information streams, extensive penetration of information and communication technologies into all spheres of life, and also emergence of new actual vital and professional challenges which are necessary for solving to school leavers. Within such understanding the role of the identity of the school student in the course of training increases. There is a need of understanding and developments of the key psychological abilities necessary for the school leavers.

To such important psychological abilities of the personality which are fixedly studied by psychologists, philosophers, sociologists the last two decades it is necessary to include the ability for reflection. Basing on the analysis of the literature (Vygotsky, 1956; Meshcheryakov and Zinchenko, 2003; Karpov, 2003; Rybinshteyn, 1946; Semenov and Stepanov, 1982) it is possible to define a reflection as universal property of mentality, a peculiar form of acquisition of personal experience, conscious and any process of judgment and reconsideration by the subject of the relations with the social world which is shown during its communication with other people and active assimilation of new social norms by him/her and forms of the behavior, providing to him/her success and productivity of activity.

There is a number of the scientific problems connected with a psychological phenomenon of a reflection. First, the problem of conceptual definition of reflexive abilities is the fact that there are certain contradictions and variations in their terminology. Secondly, the problem of development of reflective abilities, and also definition of their role in formation of an independent position of the school student in educational activity is one of complex, many-sided and actively developed in the humanities.

V.V. Davydov noted that formation of a reflection begins at younger school age, and at teenagers becomes the main mechanism of regulation of behavior and personal self-development (Davydov, 2006). The reflection gains the special importance at a stage of a professional choice and formation during training in high school (Mukii and Siurin, 2012). At the age of 13-17 years the teenager aspires to create an internal position («Who am I?», «What should I be?»), relation to other people, to moral values. At this stage the teenager plans an individual educational route. He or she needs to develop reflexive skills that will enable him to successfully adapt to the training.

The lack of elaboration of the methodological apparatus for the research of reflective abilities of school students at a stage of professional identity has led to selection of our goal: to study features of development of reflective abilities of school students in the conditions of profile training at a stage of professional self-determination.

The scientific novelty of the results of the study is that the levels and conditions of school students' reflexive abilities at the stage of professional self-determination are defined. Practical recommendations on the use of advanced psychological, pedagogical and computer technology as instrument of development of reflective abilities of school students are developed.

Methodology

The psychodiagnostics complex was developed for the empirical study of reflective spheres of students' personality. It includes:

1. Methods of A.V. Karpov and V.V. Ponomariova "The meaning of degree manifestation of the personality's reflexivity" – the definition of the reflexivity development levels;
2. The questionnaire of A.S. Sharov "Reflexivity in the vital activity of a person" – the definition of the temporary measure, the characteristics of the scope of functioning and regulatory trends of reflexivity;
3. The questionnaire of M. Grant "Studies of assessing the level of intensity and focus of subject's reflection" – a comparison of self-reflection and socio-reflection;
4. Diagnostic of valuable orientations by M. Rokich – determination of significant values for the respondents;
5. Diagnosis of the motivational structure of the personality by V.E. Milman – defining a leading motivational direction of the students;
6. The test itself-actualization – definition of capabilities of personality for actualization;
7. The self-test questionnaire of V.V. Stolin, S.R. Panteleeva;
8. Cattell questionnaire "16 personal factors" – the definition of personal qualities and characteristics;

9. The questionnaire “The style of self-regulation of behavior” by V.I. Morosanova – identification of important and relevant to the students’ self-regulation skills;
10. The questionnaire of J. Holland – definition of professional orientation of the person;
11. Technique to study the level of empathy trends by I.M. Yusupov – determining the presence of empathy at students.

For processing of results statistical methods of data processing - the factor, correlation and dispersive analysis were used. The factor analysis was carried out using principal component method “Varimax-rotation” (using a computer program Statistica⁶).

The study involved 198 students of the Kharkiv gymnasium No. 14. The age of respondents was from 14 to 18. There were three stages of the study (2011-2013).

Due to the age features and psychological distinctions at stages of profile education respondents were divided into 2 groups: the I group made of 75 students of 14-16 years, and the II group – 123 school students of 16-18 years.

Such distribution of respondents is caused by features of educational process at schools of Ukraine. In our country the high school has three stages: primary (grades 1-4, 6-10 years of age), basic (grades 5-9, 10-15 years of age) and profile (grades 10-11, 16-18 years of age).

Profile education is a system of the organization of secondary education in which a high school education takes place in different curricula (profiles) with a predominance of certain subjects. Profile training is aimed at implementing a student-centered learning process. This significantly expands the possibility of building by student the individual learning paths.

Results and discussion

Determination of school students’ reflexivity levels at stage of professional self-determination.

The first stage of detection of features of development of reflective abilities is the determination of levels of reflexivity among two groups of respondents. At interpretation of results it is expedient to start with differentiation of individuals on three main scales on categories of levels of development of a reflection: 1 – a low level of development, 2 – the average level of development, a scale 3 – a high level of development. The analysis of results shows that all school students of the I group (14-16 years) have the low and average level of general reflection development. While 10% of the students in group II (16-18 years) are characterized by a high level of development of the total reflection. The results are shown in figure 1.

Summarizing the data obtained by the method A.V. Karpov, we can say that just at the age of 15-18 years a qualitative changes in the field of personality reflexivity occur, increases the level of individual manifestations of this important indicator.

The second step of diagnostic is to determine the features of the development of reflection depending on the profile (curriculum) of the respondents. Among the 123 high school students of Kharkiv gymnasium number 14, 81 respondents attended classes of humanitarian (linguistic) profile, 22 respondents - mathematical and 20 - information technology profile. The results obtained by method A. Karpov, V.V. Ponomariova presented in figure 2.

The analysis shows that the greatest number of respondents with a low level of

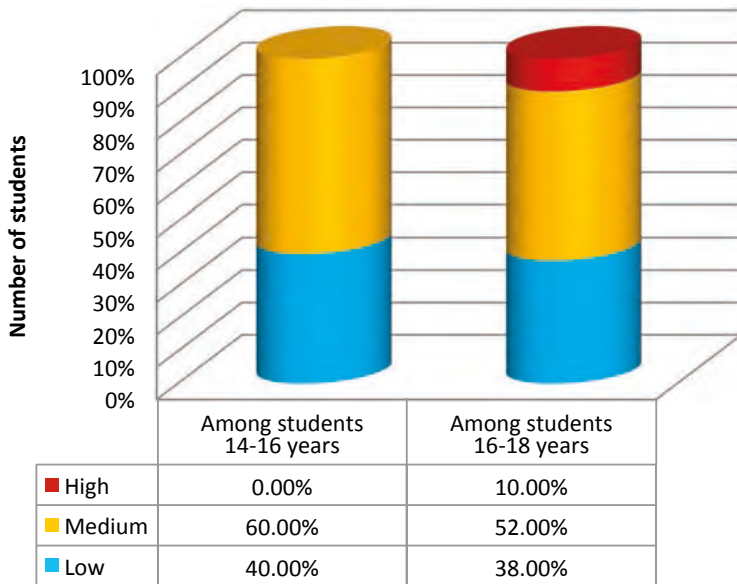


Figure 1. Comparison of levels of reflection among students in groups I and II.

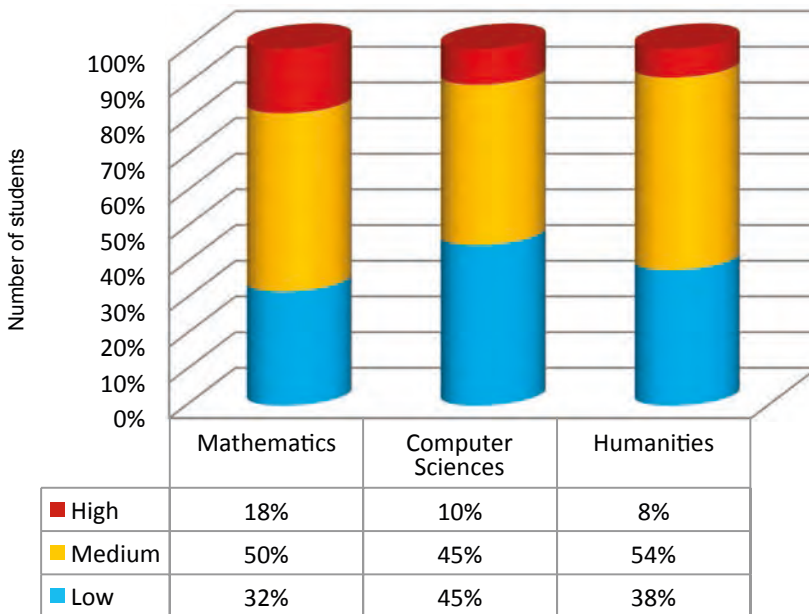


Figure 2. Comparison of school students' reflection level in different profile of study.

development of reflexivity studies in a class with an information and technological profile (45%). The highest indicator of the average level of development of reflexivity at the respondents who are training on a humanitarian profile (54%). The highest level of development of reflexivity is observed in group with a mathematical profile of training (18%)

that for 8% more than in group with an information and technological profile and for 10% more than at group with a humanitarian profile. We can say about that fact that those abilities, skills which are got by school students in the course of training on mathematical profile are optimum for development of such psychological phenomenon as a reflection. We consider that certain psychological, strong-willed, regulatory, emotional, cognitive features of consciousness of the school students who have chosen a mathematical profile of training, are the favorable base for reflexivity development at an early stage of professional identification and development.

Determination of features of development of reflective abilities

For the purpose of determination of features and factors of development of reflective abilities at school students at a stage of professional self-determination we used the factor analysis. This method of the multidimensional statistical analysis allowed to allocate the following groups of factors on the basis of experimental supervision:

- *1 group of factors: «reflective abilities according to temporary characteristics and life spheres».* This group of factors included the following elements (in parentheses the factor loadings are specified): retrospective reflection (0.89937), situational reflection (0.91489), perspective reflection (0.95409), vital reflection (0.92442), social (0.93108), cultural (0.92370), reflective abilities to self-construction (0.88313), self-affirmation (0.91625), self-regulation (0.91726). Therefore, for development of the identity of students formation of their reflective abilities is significant and necessary. They are shown in all spheres of life and are directed on reflection in consciousness of the student of his past, the present and the future. Thus, features of development of the personality at a stage of professional self-determination is ability to correlate to a situation own actions, to coordinate, supervise the acts according to changing conditions (a situational reflection); abilities to complete understanding and structuring the experience received in the past, to identification of possible mistakes, search of the reason of own failures and successes (a retrospective reflection); abilities to designing, planning of the most effective ways of activity in the future (a perspective reflection).
- *2 group of factors: «ability to self-actualization».* The following elements belong to this group of factors (in parentheses the factor loadings are specified): scale of support (-0.950729), scale of valuable orientations (-0.819286), scale of flexibility of behavior (-0.754284), scale of self-esteem (-0.849881), scale of self-acceptance (-0.728808), scale of a synergy (-0.758292), scale of acceptance of aggression (-0.849649), sociability scale (-0.772001). These data allowed to draw a conclusion on such features of development of the identity of school students at a stage of professional self-determination: the group of respondents has high degree of dependence, conformism, low degree of flexibility in realization of the values in behavior, low ability to appreciate the advantages, positive properties of character. More often students are dependent on opinion of society on the merits and demerits. School students of the senior classes are not capable fully to complete perception of the world and people, to fast establishment of deep and close emotional contacts, are not capable to accept the irritation, anger and aggression as natural manifestation of a human nature. High correlation indicators of interrelation tributes of scales and reflective abilities (not less than -0.32, $p < 0.01$) testify that development of qualities of the being self-actualization personality is a necessary condition for development of reflective abilities.

- 3 group of factors: «*educational abilities*». The following elements belong to this group of factors (in parentheses the factor loadings are specified): history (0.893069), biology (0.885837), physics (0.857092), chemistry (0.817042), world literature (0.817381), geometry (0.813353), geography (0.807090), Russian (0.808963), algebra (0.757470), English (0.711580). Positive correlation connections with reflective abilities also were observed at informatics (0.30, $p < 0.01$) and computer technologies (0.31, $p < 0.01$). Thus, knowledge, the skills, which school students receive during studying of the specified subjects are the most significant for their personal development, and also for development of their reflective abilities. In the previous works we in details considered conditions and ways of development of reflective abilities of school students in the course of studying of computer technologies and informatics (7). Prospects of further research is specification and disclosure of these conditions for other subjects.
- 4 group of factors: «*abilities to a self-reflection and socio-reflection*». The following elements belong to this group of factors (in parentheses the factor loadings are specified): the global self-relation (0.823877), the expected relation from others (0.871101), self-interest (0.859668), the relation of others (0.754534), expressiveness of installation on self-interest (0.811537). Data show that features of development of the personality at a stage of profile training is existence at students of ideas of the maintenance of “self-concept”, and also “self-concept of the professional”. Important features of development of the personality, proceeding from this factor, are development of internal feeling of pros and cons itself, interest to own thoughts and feelings, confidence of the own importance for other, expectations of the positive relation from people around.
- 5 group of factors: «*creative abilities and motivational orientation*». The following elements belong to this group of factors (in parentheses the factor loadings are specified): creative activity (0.764032), social utility (0.755856), “working” orientation of the personality (0.767202), social status (0.778467), all-vital motivational profile of the personality (0.915931). Proceeding from these data, important feature of the personality at a stage of professional self-determination is aspiration to increase of the social status, creative activity, originality, creativity, abilities of the personality independently to find «search zones», to put tasks, to allocate the principles underlying these or those designs, to transfer knowledge, skills and abilities from one area to another, itself to be based on labor activity, to develop creativity and the desire to achieve success in work. Thus, improvement of all these qualities of the personality will allow to transfer development of reflective abilities on new, better level, will aim the school student at choice of profession in which he can realize the abilities and inclinations in the best way.

Prospects of use of diagnostics results of school students' reflection

The close correlation interrelation of the listed factors and reflective abilities grants to us the right to consider them as the necessary conditions for development of students' reflexivity at a stage of profile training in high school.

Therefore, development of reflective abilities of students lies on a way of improvement of abilities to planning, modeling, designing, self-control, self-motivation, forecasting, self-affirmation, self-construction, structuring activity, abilities to establishment of deep and close emotional contacts, to creative activity, critical thinking, to complete perception of the world and people. Proceeding from it, the major pedagogical task is designing of special

problem situations and the organization of reflective activity of the students directed on their decision. For development of these abilities we consider necessary to use the advanced psychological, pedagogical and computer technologies in a complex. For the purpose of development of reflective abilities of students we developed and systematized practical recommendations on use of a complex of productive learning and teaching methodologies. The specified recommendations were created in three main directions: psychological, pedagogical and also computer technologies. Each direction is presented by the block of means (instruments) and forms of the organization of pedagogical influence on development of personal qualities of students. They include specialized trainings, psycho gymnastics, a complex of innovative teaching methods, specialized computer program and methodical complexes. Additional information on structure, the contents, forms of use of ICT for development of reflexivity of students is presented in our article (Mukii and Siurin, 2012). These recommendations and complex of learning and teaching methodologies was tested in Kharkov gymnasium No. 14 and showed positive results.

Conclusions

1. It is established, that exactly at the age of 15-18 years are high-quality changes in the reflective sphere of the personality that is shown in increase of degree of expressiveness of this phenomenon at school students.
2. It is revealed that the indicator of development of a reflection of students correlates with a training profile. So, the students who have chosen a mathematical profile of training possess higher initial indicators of level of reflexivity, than their age-mates who have chosen a humanitarian or computer profile of training. The interrelation between a level of development of reflexivity and success in studying of subjects of a natural and mathematical profile is established also.
3. Features of development of personal abilities of studying senior classes are generalized and systematized. Among them such groups: reflective abilities according to temporary characteristics and life spheres, self-actualization, educational, creative abilities and a motivational orientation, and also abilities to a self-reflection and a socio-reflection.
4. Practical recommendations on use of the advanced psychological, pedagogical, computer technologies as instrument of development of students' reflective abilities were created.

References

- Davydov V.V. (2006). *Lectures on educational psychology*. p. 224 c.
- Vygotsky L. (1956). *Selected psychological studies*. pp. 519.
- Meshcheryakov B. & Zinchenko V. 2003. *Large psychological dictionary*. pp. 672.
- Karpov A. (2003). Reflexivity as a mental property and method of diagnosis. *Journal of Psychology*, 24 (5): 45-57.
- Rybinshteyn S. (1946). *Being and consciousness*. pp. 704.

Semenov I., Stepanov S. (1982). *Types and functions of reflection in scientific thinking: Problems of reflection in scientific knowledge*. pp. 76.

Mukii T., Siurin O. (2012). *Advanced computer technologies as an instrument for student's virtual reflection development*. Madrid, International Association of Technology, Education and Development. Title: ICERI2012 Proceedings, ISBN: 978-84-616-0763-1, pp. 5997–6006.

ISLAND ECOSYSTEM AND INVASIVE ALIEN SPECIES – ISLANDS AND IAS

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Abstract – This paper describes the project proposal ideated by the *Gorgona Social Cooperative* (Livorno, Italy) on environmental education on Invasive Alien Species (IAS): *Island Ecosystem and Invasive Alien Species - ISLANDS and IAS* in the territory of the National Park of the Tuscan Archipelago. By applying the training methodologies of *Gorgona Social Cooperative* environmental guides during educational programs, the project aims to involve pupils on practical activities to raise their awareness on environmental issues related to the presence of IAS in nature (<http://ec.europa.eu/environment/nature/invasivealien/> : Invasive Alien Species – Environment – European Commission). They carry out a field trip on a selected island of the Tuscan Archipelago National Park, in which they have to identify, localize and represent on a thematic map the presence of using original educational instruments elaborated by *Gorgona Social Cooperative* as well as material provided by the Park authority, developed in the frame of the COREM project (Cooperation of the Mediterranean Ecological Networks).

The educational program, based on the naturalistic hiking culture, and leads to the naturalistic knowledge of a certain area, examining its natural and anthropogenic transformations throughout history and time, and focusing on the impacts of invasive alien species.

Keywords: alien species, biological invasions, ecosystem studies, Tuscan Archipelago, vegetation dynamics

Introduction

In the teaching program of the Italian school system, environmental education has become more and more present over the years. One of the main aims of the *Gorgona Social Cooperative* is the transfer of natural environment value and importance of biodiversity conservation to young generations. Therefore, *Gorgona Social Cooperative* offers to schools of all types and grades, environmental education projects that include field activities during field trips of 3-5 days on marine and terrestrial ecology. The project *Island Ecosystem and Invasive Alien Species – ISLANDS and IAS* is a proposal to schools, to plan an educational trip in the territory of the National Park of the Tuscan Archipelago.

Islands constitute peculiar, fragile, ecosystems. In particular they suffer a reduction in biodiversity due to the introduction of invasive alien species (IAS), therefore, based on this concern and on the long experience on environmental education, the *Gorgona Social Cooperative* provides a project proposal titled *Island Ecosystem and Invasive Alien Species – ISLANDS and IAS* to be developed in the local territory.

The specific objective of *ISLANDS and IAS* is the realization of a thematic map on invasive alien species on the territory of the National Park island in which the field trip with students can be carried out (Figure 1).



Figure 1. Capraia Island (Tuscan Archipelago National Park).

Other aims are also reached, such as knowledge transfer on nature, islands history and Mediterranean island ecosystems, in addition to the development of pupils curiosity and other skills.

Pupils are introduced to natural issues of introducing IAS in terrestrial (as well as marine) ecosystems, main limit to the local biodiversity (Figure 2).

They learn to recognize and identify alien species: pupils may have seen them just because they are very common, but people don't know their dangerousness for biodiversity (<http://www.isprambiente.gov.it/it/temi/biodiversita/documenti/europea-e-mediterranea/towards-an-early-warning-and-information-system-for-invasive-alien-species-ias>).

Then they learn to use cartographic tools for localization of IAS and improve their skills of teamwork, questioning and elaborating reasonable answers.

Moreover, pupils face with sustainable style of living in the area and have a direct contact with nature and territory.

ISLANDS and IAS targets to all grades of schools (primary, secondary – middle and high – schools), through communication paths retailed on the pupils' age and their base knowledge. Moreover, the project aims to an active and participative involvement of pupils and also, it can be implemented in both terrestrial and marine ecosystems (authorization required for snorkeling in shallow waters).

Methodology

The activities proposed to the class, are carried out mainly on site, during field trip of 3-5 days on a selected island. Some teachers may require an in classroom introductive lesson, before the field trip.

Each field trip involves one class (about 20/25 students) and consists of 5 phases.



Figure 2. *Carpobrotus acinaciformis*.

First phase: Propedeutic phase.

Presentation of environment and issues. This phase is preparatory and introductive to the environmental issue of IAS. Pupils assist to a general presentation of the ecosystem peculiarities, in particular the endemic species of flora and fauna of the island on which they will carry out the field trip, then, they have to fill a questionnaire on IAS provided by the Tuscan Archipelago National Park (CO.R.E.M., <http://www.projectcorem.eu/>).

Second phase: Knowledge by looking

Field trip on the island. There, working groups of 4-5 pupils are organised and pupils are encouraged to look around and read the territory. They should identify the presence of different ecosystems and take pictures (Figure 3). The pictures collection are showed to all other pupils in order to debate together on the territory interpretation and to get also further knowledge on the territory, its current vegetal invasions in relation to the management changes over time.



Figure 3. Excursions and picture shoots.

The discussion brings out the concepts of “evolution” and “degradation” of an ecosystem and the thematic of threats for biodiversity. The problem of introduction and spreading of alien species in the insular systems is furthermore deepened and the current IAS in the selected island are showed. Environmental guides identify suitable areas for the realization of the educational project in which pupils survey the presence of IAS (NEMO: Nature and Environment Management Operators srl <http://www.nemoambiente.com/node/95>).

Third phase: Knowledge by doing

This is the operative phase of the project. Pupils learn how to use useful tools for the cartographic survey (maps, compasses, GPS, depending upon the pupils’ age) and they collect data through the fieldwork. The class is divided into working groups. Each group has an assigned area where it has to survey and map the presence of IAS. Data collected concern: position (geo-referenced and cartographic) and extension of the colonization and photographic material.

In the same area pupils carry out also the vegetation survey and land cover, noting the information on a blank topographic map of the territory. If wildlife is seen, the species and the place of sighting are noted on the map.

The results of each working group are put together with those of the other groups, in order to achieve a map of the project area including all collected data.

Fourth phase: Final elaboration

The results are discussed collectively. If possible, the current land cover is compared to historical maps or documents. Then, pupils produce a final report with data and results.

Conclusions

ISLANDS and IAS is a project proposal which can be concretely implemented due to the long experience of the *Gorgona Social Cooperative* on environmental education and special interest on IAS environmental issue.

The project aims to raise the awareness of pupils on environmental problems through an active learning by looking, doing and debating. Critical thinking and active citizenship can be stimulated by the project phases, moreover, their field work might be a useful tool for the National Park Authority which would benefit of field survey on IAS spreading area and likely new IAS.

Web references

COREM: <http://www.projectcorem.eu/>. Accessed: September 3, 2013.

European Commission. Invasive Alien Species. Available at: <http://ec.europa.eu/environment/nature/invasivealien/>. Accessed: September 3, 2013.

NEMO: <http://www.nemoambiente.com/node/95>. Accessed: September 3, 2013.

Istituto Superiore per la Protezione e la Ricerca Ambientale. Available at: <http://www.isprambiente.gov.it/it/temi/biodiversita/documenti/europea-e-mediterranea/towards-an-early-warning-and-information-system-for-invasive-alien-species-ias>. Accessed: September 3, 2013.

TEACHING EARLY MATHEMATIC IN SCHOOL USING INFORMATION AND COMMUNICATIONS TECHNOLOGY. INTERVENTION EVIDENCE-BASED

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Abstract – In the school-age population, the prevalence of mathematics disabilities is 5%-9% (Geary, 2004; Jordan, 2007). Lifelong opportunities associated with math disability form a critical problem. Math skills accounts for an important part of the variance in work productivity, income, and employment, even more than reading and intelligence (Fuchs *et al.*, 2009). It is therefore important to search for ways to prevent mathematics difficulties. Research shows that early intervention activities can substantially improve math performance (Clements and Sarama, 2007). However, not all approaches are effective for all students. For example, after a one-year prevention program for first-grade students, approximately 3%-6% of the school population continued to manifest severe mathematical deficits. This study evaluated the effectiveness of educational intervention software, *Playing with Numbers-2* on early mathematics learning. This software trains learning and mathematical reasoning skills, using an evidenced-based procedure. A total of 128 second-year preschool boys and girls (Mean age = 53.28 months) were assessed by the Early Numeracy Test (ENT), a computerized test to evaluate early math competency. We used an experimental design with control group and pre and post-intervention assessments. The experimental group (n = 30) was composed by students from each classroom with the lowest ENT scores (≤ 19). Control group (n = 98) was composed by all the other students across classrooms. The intervention was carried out during 30 sessions (3 sessions per week, 30-45 minutes each), using the software, *Playing with Numbers-2*. The experimental group significantly improved the ENT scores, outperforming the control group mean score. Significant differences between pre- and post- intervention for the experimental group were obtained ($t = 13,037$, $p < .005$). The average increase for ENT scores achieved by the experimental group was significantly higher than the control group. The intervention effect size showed higher values for the experimental group ($d = 2.75$, $r = .80$). This groups' score was higher than the control group in all of the ENT subtests and over the total test. This educational intervention using computer-based software, while it does not replace face-to-face instruction, may help to improve the performance of young students at risk of developing problems learning mathematics.

Keywords: early mathematics, Early Numeracy Test, low math achievement, Playing with Numbers-2

Introduction

Mathematical performance contributes an important part of the variance ascribed to income, employment, and work productivity, even more than intelligence. In the school-age population, the prevalence of mathematics disability is 5%-9%, and lifelong opportunities associated with math disability form a major barrier to school and later career success (Fuchs *et al.*, 2009). It is therefore important to investigate if early mathematic assessment

and treatment can improve math performance (Clements and Sarama, 2007; Navarro *et al.*, 2012). The early identification of children at risk of lower mathematical achievement is needed because of the major impact it has on school and life for every student.

Considering the importance of early math learning in schools, and the use of new ICT teaching methodology, the authors present different aspects of assessment and intervention in early math for young children applying an evidence-based procedure. The main aims of this presentation are:

- a. To identify the cognitive processes that underlies the individual differences in early mathematical performance in elementary school children. Taking into account the Baddeley (1997) framework multicomponent model, the inhibitory processes, working memory, phonological awareness, and naming speed are thought to be related to early math learning.
- b. To present an early math intervention program with preschool Spanish children. This program is a piece of software, *Playing with Numbers II*. The activities of *Playing with Numbers II* are designed within the theoretical framework of Gelman and Gallistel (1978) and Piaget (1965). The software includes activities aimed at learning the concepts related to the development of abilities such as: comparison, classification and seriation of objects and combination and distribution as problem-solving strategies. Lastly, the software introduces, “*The Number Line*” activities, which consolidates counting skills.

Methodology

Procedure: A total of 128 second-year preschool boys and girls (Mean age = 53.28 months) were assessed by the Early Numeracy Test (ENT), a computerized test to evaluate early math competence. An experimental design with control group and pre and post-intervention assessment was used. The experimental group ($n = 30$) was composed of students from each classroom with lowest ENT scores (≤ 19). Control group ($n = 98$) was composed by all the other students. The intervention was carried out during 30 sessions (3 sessions per week, 30-45 minutes each), using the software *Playing with Numbers 2*.

Materials: The software program presented in this paper targets the learning of specific math concepts. Stressing the importance of significant mathematical learning for all students, Nunes *et al.*, (2007), have suggested that the basis of the development of maths skill in children is logical thinking, and the learning of conventional number systems. The software, *Playing with Numbers 2*, includes activities aimed at learning the concepts related to number acquisition and counting ability, the development of concepts of comparison, discrimination, seriation and problem-solving. Eleven different computer games are included in the software:

1. “*Learning to Count*” consists of 5 counting activities that help students start learning the number sequence, through activities designed to differentiate between counted and uncounted objects. It has four sub-programs, each with a different level of difficulty based on four variables: (a) whether the number of objects is the same or different to the number the program requires the student to count, (b) if the program speaks/vocalizes the number when the object is touched or not, (c) if the number required appears on the screen, and (d) if the objects appear in order or out of order. The difficulty

of the different levels is shown by whether the object counted disappears, is modified or remains unchanged.

2. “*Number Chain*”. This program strengthens student learning of the number sequence through activities aimed at the acquisition of forwards and backwards counting, starting from a predetermined number less than ten. These activities allow not only the acquisition of the number sequence, but the ability to discover, through doing operations, how many numbers there are between the two requested numbers. It has two sub-programs with nine levels of complexity: in the first four levels (N1, N2, N3, N4) the activities focus on counting forwards, the following four (N5, N6, N7, N8) focus on counting backwards. The last level (N9) asks for the number of squares between the two numbers indicated, requiring forwards or backwards counting.
3. “*Calculation*”. The program aims to develop the concept of the cardinal value of numbers through practical activities. By presenting different tasks, students will discover that the last number of the counting process represents the value or quantity of the specific set of objects counted. The program consists of five activities that randomly ask students to indicate how many objects there are, the number varying from 1 to 20. In each of the activities, the computer asks the student to count how many items appear on the screen and indicate the number on the calculator that appears on the right of the screen.
4. “*Number Cruncher*”. This aims to develop the graphic discrimination of numbers, and the association with their respective label, through practical activities. At the end of the program, a screen appears showing the following information: the number of correct answers, number of errors, number of intermediate errors and the final score.
5. “*Comparison*”. By presenting different tasks and levels of complexity, students discover the differences and similarities between two or more situations. The program features activities designed to differentiate between two objects and differentiate objects from a model. It has two subprograms: “Comparisons Level 1” and “Comparisons Level 2”.
6. “*Classification*”. This helps the student to start learning the concept of object grouping. By presenting different tasks, students will discover classification and the possibility of distinguishing between objects and groups of them. It has three levels of difficulty. Each level has 3 activities aimed at grouping objects by one feature, the number of cubes per colour in level 1 and 2 is always the same and in level 3 each group of cubes is different.
7. “*Ordering*”. This program helps the student to start learning the concept of object ordering. By presenting different tasks, students will discover order in a series of discrete objects according to a specific characteristic. It has three levels of difficulty. There are several activities aimed at discriminating groups of objects (level 1) or groups of numbers (level 2 to 9 and level 3 exercises 10 to 20) that are ordered, from those which are not.
8. “*Combination*”. Students start to learn “part and whole” problem-solving. They work on static problems in “Combination I” in which they are given the details of both parts and they are asked for the whole and in “Combination Level 2” the whole and one of the parts appears in the statement of the problem and they are asked for the other part.
9. “*Discrimination*”. The activities in this program aim to teach the child to differentiate between the cardinal value of numbers and the physical size of their representation. To

this end, we present three sub-programs with different levels of complexity depending on whether the numbers have one, two or three digits and whether the two numbers being compared are the same size or a different size, with no relationship between the cardinal value and the physical size (Figure 1).

10. “*Distribution*”. This program involves the ability to distribute a group or groups of objects into equal or unequal groups via problems in which a number of objects has to be shared among a number of subjects with the requirement that each has the same number of objects. The difficulty increases when we change the number of subjects or we increase the number of objects to be shared.
11. “*The Number Line*”. This strengthens counting ability through Number Line activities. The program asks the child to indicate a number on the number line. There are four sub-programs where the level of difficulty lies in the sequence of numbers presented (from the easiest level, where there are ten single digit numbers, to the following levels where twenty, two-digit numbers are presented, sometimes at random) or in the presentation of all, some or only the beginning and end of the sequence (the missing number is replaced by a line). The first, last and middle numbers are represented by a circle, the position of other numbers with a line.

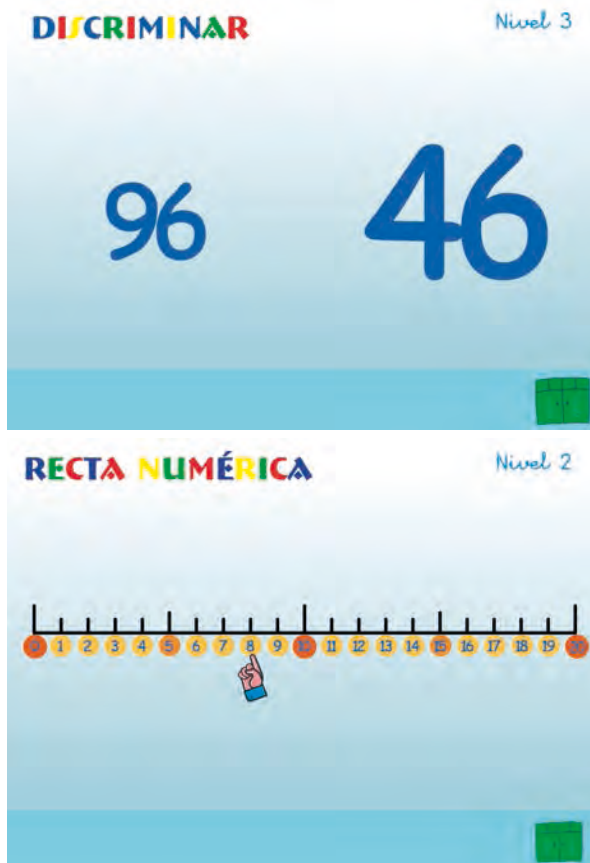


Figure 1. *Playing with numbers 2.* Some examples of *Discrimination* and *The Number Line* activities.

Results and discussion

Descriptive results were calculated before and after intervention using the Spanish version of the Early Numeracy Test-R as a dependent variable (Table 1). On pre test phase, control group was $Mean = 24.34$ ($sd = 5.57$), and experimental group $Mean = 14.33$ ($sd = 2.61$).

Table 1. Descriptive results (*mean* and *sd*) for experimental and control groups before and after intervention using the Spanish version of Early Numeracy Test-R.

		PRE-TEST		POST-TEST	
		<i>Mean</i>	<i>sd</i>	<i>Mean</i>	<i>sd</i>
Experimental Group	Piagetian tasks	9.20	2.64	13.93	2.31
	Numerical tasks	5.13	2.04	12.07	3.75
	Total Test	14.33	2.61	26.00	5.46
Control Group	Piagetian tasks	12.69	2.67	12.56	2.46
	Numerical tasks	11.64	4.13	12.91	3.76
	Total Test	24.34	5.57	25.47	5.16

Mean score for all participants' show positive increments after intervention, in both numerical and Piagetian tasks. All participants increased scores in second evaluation. Differences in math competency were significant ($t = -13.037$; $p < .005$). After intervention, the control group increased the ENT-r scores reaching equivalent results than experimental group, reducing the gap between both groups.

Gains obtained by experimental group after intervention were higher than control group scores for total test and different subtasks (Table 2). The math achievement for experimental group participants reached a $Mean = 11.6$ points, and for control group participants increased was just $Mean = 1.63$ points. Intervention had a positive impact especially for Piagetian tasks. Increasing scores for numerical tasks were lower than Piagetian tasks such as control group (increment score = .03) as experimental group (increment score = .73). Differences between pre and post intervention for control group were almost zero.

Table 2. Increase score for the Spanish version of Early Numeracy Test-R., after intervention sessions using "Jugando con Números-2" [Playing with numbers-2] software (post-test phase).

	EXPERIMENTAL GROUP		CONTROL GROUP	
	<i>Mean</i>	<i>sd</i>	<i>Mean</i>	<i>sd</i>
Total Test	11.67	4.90	1.13	4.61
Piagetian tasks	4.73	2.71	.13	2.63
Numerical tasks	.73	1.23	.03	.80

Considering the study characteristics, the *effect size* was calculated to determine the treatment impact of the experimental group. The value for effect size was the truncated Cohen's d (1988). Mean differences between pre test and post test were calculated by dividing the intra-group standard deviation. Data shows that experimental group had a progressive score increasing with significant differences between pre and post treatment ($d = 2.75$; $r = .80$) for the Spanish version of Early Numeracy Test-R score. However, data were not significant for control group ($d = .19$; $r = .095$).

Conclusions

The main purpose of this presentation was to discuss an intervention program with preschool Spanish children in early math. This program was designed using the theoretical framework of Gelman and Gallistel (1978) and Piaget (1965). It included activities aimed at learning concepts related to the development of specific mathematical skills such as: comparison, classification and seriation of objects, and the combination and distribution of problem-solving strategies. Lastly, the software introduces, “The Number Line” activities, which attempts to consolidate counting skills.

After the training sessions, results show that the experimental group significantly increased ENT-b scores, and differences between good (control group) and bad math performers (experimental group) were dramatically reduced. There were no gender differences between groups. Those results are similar to other mathematical training programs that used somewhat different methodologies (Clements and Sarama, 2007), and may be useful predictors for future math failure in young children (Siegler and Ramani, 2009). This is particularly important because of the implications for developing “number sense” in early math learning.

If the Piagetian and numerical tasks are considered, the training program significantly increased performance for Piagetian over the numerical ENT-subtests. This was an interesting finding because early math learning may require both Piagetian and numerical tasks as has been considered by different studies (Bryant, 2005; Fuchs *et al.*, 2009). However, the Estimation task was clearly the most difficult ENT-subtest for both high and low performers. This suggests that task adjustment is a key issue in order to improve efficiency of students using *Playing with numbers-2*.

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References

- Baddeley A. (1997). *Working memory*. Oxford, UK: Clarendon Press.
- Bryant D.P. (2005). Commentary on early identification and intervention for students with mathematics difficulties. *Journal of Learning Disabilities*, 38, 340-345. doi: 10.1177/00222194050380041001.
- Clements D.H. & Sarama J. (2007). Building blocks for early childhood mathematics. *Early Childhood Research Quarterly*, 19, 181-189.
- Fuchs L.S., Powell S.R., Seethaler P.M., Cirino P.T., Fletcher J.M., Fuchs D. & Zumeta R.O. (2009). Remediating number combination and word problem deficits among students with mathematics difficulties: A randomized control trial. *Journal of Educational Psychology*, 101, 561-576. doi: 10.1037/a0014701.
- Gearry D.C. (2004). Mathematics and learning disabilities. *Journal of Learning Disabilities*, 37, 4-15. doi: 10.1177/00222194040370010201.
- Gelman R. & Gallistel C. (1978). *The child's understanding of number*. Harvard University Press, Cambridge, MA.

- Jordan N.C. (2007). The need for number sense. *Educational Leadership*, 65, 63-66.
- Navarro J.I., Aguilar M., Marchena E., Ruiz G., Menacho I. & Van Luit H. (2012). Longitudinal study of low and high achievers in early mathematics. *British Journal of Educational Psychology*, 82, 28-41. doi: 10.1111/j.2044-8279.2011.02043.x
- Nunes T., Bryant P., Evans D., Bell D., Gardner S., Gardner A. & Carrahe J. (2007). The contribution of logical reasoning to the learning of mathematics in primary school. *British Journal of Developmental Psychology*, 25, 147-166. doi: 10.1348/026151006X153127.
- Piaget J. (1965). *The Child's Conception of Number*. Norton, New York.
- Siegler R.S. & Ramani G.B. (2009). Playing Linear Number Board Games – But Not Circular Ones – Improves Low-Income Preschoolers' Numerical Understanding. *Journal of Educational Psychology*, 101, 545-560. doi: 10.1037/a0014239.

CONCEPT MAPPING STRATEGY, LECTURE METHOD AND STUDENTS' ACADEMIC PERFORMANCE IN CALABAR MUNICIPALITY, CRS, NIGERIA

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Abstract – The research work investigated the influence of concept mapping strategy on SS2 Chemistry Students' academic performance in Calabar Municipality, Cross River State, Nigeria. A total of 120 (SS2) Chemistry students were selected from four (4) secondary schools through simple random sampling technique. Sixty (Experimental group) were taught selected Chemistry concepts with concept maps and another sixty (control group) were taught Chemistry concepts without concept maps. Chemistry students. A validated Chemistry Achievement Test (CAT) was used to gather data for the study and a split-half was carried out using Pearson product moment correlation coefficient of 0.78. Independent t-test was used to test the hypothesis at 0.05 significant level. The study revealed that students taught selected Chemistry concepts with the use of concept mapping strategy performed significantly better than students taught Chemistry concepts without concepts maps. This means that the use of concept mapping strategy generally improved students' academic performance. It was recommended that teachers should be encouraged to use of concept mapping strategy in teaching science.

Keywords: Concept mapping, lecture method, performance, strategy, students.

Introduction

We live in a world of science and technology. Science and technology have proven to be significantly relevant in human being's daily struggle to control his environment and live in a comfortable society. The National Policy on Education stated that, Science and technology have become critical factors of economic and social development. Through the application of science and technology the resources of nature have been well utilized and transformed into meaningful resources for a better living in the world. In spite of the tremendous emerging trends in science and technology development, Nigeria is still lagging behind in terms of comfortable living (FGN, 2004).

Fundamental research among science educators and cognitive scientist focuses on how people learn science and how they apply this knowledge in their daily lives. The primary aim of science teaching is to collect facts (data) and discern between the various facts (Gorrlieb, 2011). Science can mean concerted effort to understand the world better through search, experiments and application of different approaches.

However, every human being needs acquaintance with what science is all about. The relevance of science education cannot be overemphasized. It is eminent that Nigerian citizens should be adequately informed with the pre-requisite scientific knowledge, skills and attitudes that will enable them live comfortably and meaningfully in the society.

Nja (2012) posits that there is greater desire for Nigeria to attain reliance which has given science education an enviable status in the Nigerian educational system. Thus it reflects in the great emphasis that the Nigerian government lays on the teaching and learning of science at all levels of her educational system.

Akpan (2010) opines that the enrolment of students in science, especially chemistry has not been very encouraging. The ugly trend in students' academic performance is reflected in the external examination result (SSCE, NECO, NEBTEB and JAMB). The performance of students is an indication that all is not well in Nigeria's educational system especially at the secondary school level.

The dearth in science teaching is associated with teaching resources, teaching strategies, teachers' incompetence, lack of skills etc. Uche and Umoren (1998) opine that science being activity oriented, has been designed that it be taught through series of strategies in schools (Inquiry-based instruction, concept-map strategy, laboratory activity, etc.).

It is based on this that this study attempts to investigate inwardly the use of concept mapping strategy in teaching chemistry in secondary schools.

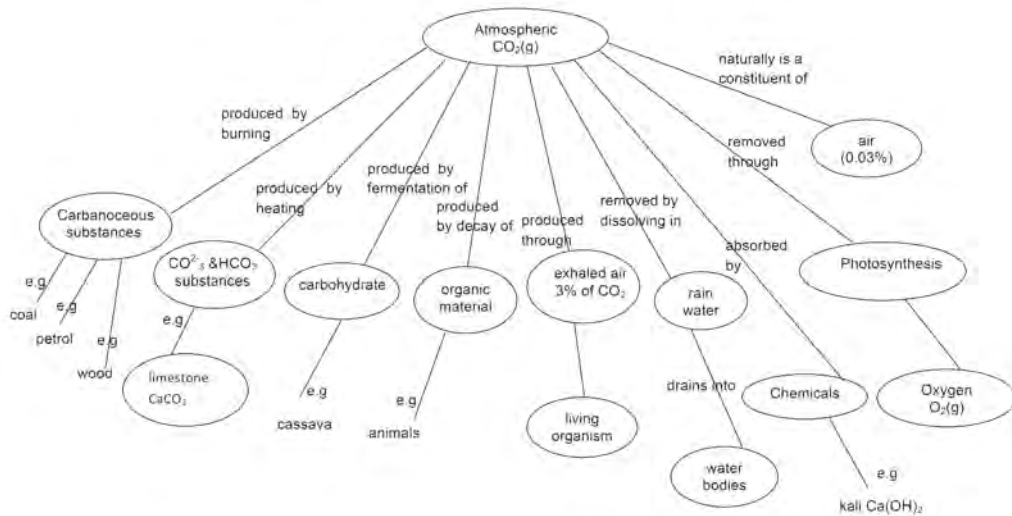
Literature is replete with the recurring decimal of rote learning in Nigeria schools, which is typical of traditional classrooms and evidenced in poor academic achievements of students in external examinations (Omosewo, 2008; Esiobu, 2005; Onasanya, 2004). Renewed efforts must be made by science teachers in general and chemistry teachers in particular, in order to make their classroom exciting, purposeful and participatory. This calls for the use of instructional approaches and strategies that will promote meaningful learning and understanding of basic chemistry concepts which are the building block of learning (Gbamanja, 2002). One of such teaching approaches which the teacher will use to translate traditional classroom to a constructivist classroom is concept mapping strategy. To what extent does teaching with concept mapping strategies affect students' academic performance when taught some selected chemistry concepts?

It is the opinion of the researcher that Concept mapping strategy, which is a sub-set of inquiry-based learning technique should be encouraged in the nation's educational system as an effective learning in chemistry strategy teaching. This study may lead the students to the knowledge of practical application of concept mapping strategy as an effective teaching technique in secondary schools. The study may help students to understand how to construct concepts using familiar words and event

A concept map is a diagram showing the relationship between concepts. It is a graphical tool for organizing and representing knowledge (Novak and Cañas, 2008). It is a flow chart of meaningful relationship between concepts in the form of propositions.

Concept mapping as an effective tool was first used by Joseph D. Novak of Cornell University in the 1970s as a way to increase meaningful learning in the sciences. Concept maps have their origin in the movement called constructivism, and particular constructionists hold that prior knowledge is used as a framework for understanding and learning new concepts. It is based on the premises that concepts do not exist in isolation but are interrelated with others to make meaning (Osisioma, 1996). Concept mapping is therefore a technique for visualizing the relationships between concepts. This view is corroborated by Okon (2012) who sees concepts mapping as a diagrammatic representation of the relationship or interrelationship of a new concept to an already known concept.

A CONCEPT MAP OF ATMOSPHERIC CARBON DIOXIDE AND RELATED CONCEPTS



A CONCEPT MAP OF CARBON AND RELATED CONCEPTS

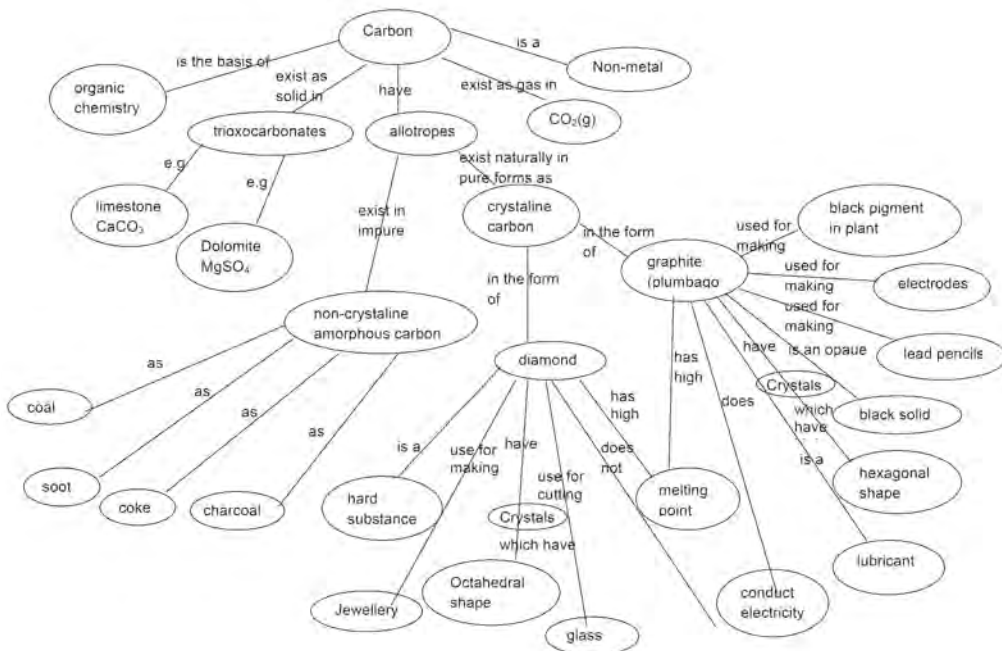


Figure 1. Concept map (Constructed by the researcher).

Methodology

A quasi experimental factorial research design was adopted for this study. The design is a modification of pretest-posttest. The experimental group was taught using concept maps.

The control group was taught without concept maps. Both the experimental and control groups were represented as pre-tested, post-tested and both were given a test to determine the effect on both groups.

The study was carried out in Calabar Education Zone of Cross River State also known as Southern Educational Zone. Simple random sampling technique was used to select the sample. The sample of this study consisted of a total of one hundred and twenty (120) senior secondary school chemistry students selected from four local government area in Calabar Educational Zone.

The instrument used for this study was researcher instrument called Chemistry achievement test (CAT). The result obtained from the split-half was subjected to analysis using Pearson product moment correlation statistics. The result obtained from the analysis shows reliability coefficient of 0.78.

Result and Discussion

The null hypothesis which states that there is no significant difference in students' academic performance when taught with and without concept mapping strategy was tested using independent t-test. The null hypothesis was rejected.

Table 1. Mean, standard deviation and summary of analysis of influence of treatment on chemistry students' performance using concept mapping and lecture method.

TREATMENT GROUP	N	X	SD	t
Experimental	60	18.63	5.74	6.83
Control	60	11.88	65.06	
Total	120	15.26	5.4	

* $p < 0.05$, $df = 58$, critical $t = 2.00$

The result of the analysis displayed in Table 1 earlier revealed that students taught selected Chemistry concepts using concepts maps had higher mean performance experimental ($x = 18.63$) in comparison to those taught chemistry without the use of concept maps with ($x = 11.88$). When the mean was subjected to analysis using independent t-test, there was a significant difference in the result since the calculated t-value was higher than the critical t-value at 0.05α – level of significance. This means that students taught selected chemistry concepts using concept maps perform significantly better than those taught chemistry using the conventional method.

The observed difference between the experimental and the control groups was due to the treatment effect using (concept maps) which made learning real, concrete and meaningful. This was in line with Ausubel's theory of meaningful learning which emphasized on constructivists view and provide an initial conceptual framework for subsequent articulation of different concept. Similarly, Udo (2003), Nwosu (2000) studies showed the importance of concept mapping strategy on students' academic performance, especially in science.

Conclusion

The researcher therefore concluded that lack of appropriate teaching strategies in the teaching of Chemistry has contributed greatly to students' poor academic performance in Chemistry. Students taught selected Chemistry Concepts with the use of concept maps performed significantly better than students taught Chemistry concepts without concept maps.

References

- Akpan E.U. (2010). Sustaining students' interest in science and technology: Implications for the preparation of science and technology teachers. *Journal of Pedagogy and Development*, 2, 16-18.
- Ausubel D. (1968). *Educational psychology: A cognitive view*. Holt Reinhart and Winston, New York.
- Esiobu G.O. (2005). Gender issues in science and technology education development. In Iwovi U.M.O. (Ed). NERDC Press. (pp. 137-156). Lagos.
- Federal Government of Nigeria (FRN) (2004). *National Policy on Education (4th ed.)*. National Educational Research and Development Council, Lagos.
- Gbamanja S.P. (2002). *Modern methods in science education in Africa*. Totan Publishers Ltd., Owerri.
- Nja C.O. (2012). *Investigating the Nigeria traditional kitchen as a resource in the teaching of thermo-Chemistry in secondary schools*. Unpublished M.Ed thesis, University of Uyo, Nigeria.
- Novak J.D. & Cañas A.J. (2008). *The theory underlying concept maps and how to construct and use them*. Technical Report IHMC Cmap Tools. <http://cmap.ihmc.us/publications/researchpapers/theory-underlying-concept-maps.pdf>. Accessed 17-05-2012.
- Novak J.D. (1990). Concept mapping: A useful device for science education. *Journal of Research in Science Teaching*, 27 (10), 937-949.
- Nwosu E.C. (2000). Resource utilization in science education (Chemistry) classroom. *41st Annual Conference Proceedings of STAN*, Awka, August 21-26.
- Okon P.A. (2012). Concept mapping strategy, lecture method, locus of control and students' academic achievement in biology. Unpublished M.Ed Thesis, University of Calabar, Calabar.
- Omosewo E.O. (2008). Physics teachers education and national reforms in education reforms in Nigeria past, present and future. In Lawal A.R. (Ed.). Sterling-Holden Publisher Ltd, Lagos. pp. 247-250.
- Onasanya S.A. (2004). Selection and utilization of instructional media for effective practice teaching. *Journal of Instructional Studies in Education*, 2, 127-133.
- Osioma U.I. (1996). Difficulty concepts in biology identification, instruction/learning strategies. A paper presented at the 35th Annual Conference of STAN, 5-20 August.
- Uche S.C. & Umoren G.U. (1998). *Integrated science perspective and approaches*. AAU Vitals Book Company, Abia.
- Udo E.E. (2003). Resource materials and strategies – A technology tool for effective teaching and learning of primary science. Presented at STAN 46th annual conference, Jos, 15–16 August.

EFFECT OF TEACHING WITH KITCHEN RESOURCES ON STUDENTS' ACADEMIC PERFORMANCE AND RETENTION IN THERMOCHEMISTRY IN CROSS RIVER STATE, NIGERIA

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Abstract – This study examined kitchen resources, academic performance and retention of SS2 Chemistry students in Thermochemistry. Thermochemical activities in the kitchen such as, fermentation of samples of five different juices, heating capacities of five samples of wood, induced thermal decomposition of five samples of shellfish shells powder and dissolution of five samples of glucose were used for the study. The sample comprised 240 students drawn from four secondary schools in Calabar Education Zone of Cross River State, Nigeria. Pretest-posttest control group quasi-experimental design was used for this study. Chemistry Achievement Test (Cat) was used for data collection. The results showed reliability coefficients of 0.89. Analysis of Covariance (ANCOVA) was used for data analysis. Findings revealed that the use of kitchen resources during the teaching of Thermochemistry enhanced the performance and retention level of students. Based on these findings it was recommended that teachers should be encouraged to adopt kitchen resources for teaching Chemistry.

Keywords: academic performance, Kitchen resources, retention, thermochemistry and students

Introduction

Generally, science education at all levels of education in Nigeria is in a deplorable state. Students' performance in senior school certificate examinations in Chemistry in Cross River State, Nigeria, have not been encouraging. The percentage of candidates who passed at credit level and above have been consistently low (below 25%) from 2005 to 2010 (West African Examination Council, 2010). A lot of assertions and empirical findings have been made to explain this poor performance. For one, there is dearth of resources for teaching science at all levels (Nbina and Obomanu, 2011; Nkanu, 2009; Ihuarulam, 2008; Opera, 2008; Oriade, 2008; Ifeakor, 2006; Udo, 2006; Okafor, 2000; Ivowi, 1999; Uche and Umoren, 1998).

This is so however, because teachers have either neglected or are not aware of kitchen resources that can be effectively used in teaching chemistry. The modern kitchen is stocked with quality materials, and is probably the safest chemical laboratory in the world (Hayward, 1992). Many activities and materials abound in the kitchen. The early days of a learner's development are centred around the home, and the kitchen. The kitchen is a unit of the home and special consideration of the home as a resource in teaching science can be seen in the light of the modern kitchen being regarded as a workshop of various practices, which expose the learner to experiences in the various aspects of Chemistry (Eshiet, 1996). Eshiet (1996) stated that a lot of activities abound in the kitchen and what a teacher needs do is careful analysis, identification and deployment of these experiences and

practices as backup knowledge in the teaching and learning of science in the classroom. Though these authors assert that the kitchen can be used to teach Chemistry, empirical research is lacking on the effect of kitchen resources on student's academic performance and retention. The purpose of the research reported here was therefore to ascertain the extent to which the use of kitchen resources in teaching affect Chemistry students' academic performance and retention in Thermochemistry. Specifically, the research question was: How does teaching with and without kitchen resources affect SS 2 Chemistry students' academic performance and retention of thermochemistry concepts?

Chemistry is all around us and affects every moment of our lives. Children love to experiment and are fascinated by chemical bang or changing colour. Harnessing this desire to experiment, in a safe and controlled way, has often meant that science lessons cannot be dull and also that they are not teacher-led affairs. The lack of suitable resources and teaching materials has meant that children often do not get to experience the excitement of making new discoveries. The kitchen Chemistry aims to change all that by bringing into the classroom all the resources and information that are needed to run experiments (Helmestine, 2010). Kitchen Chemistry was set up by Johnson (2005) to create innovative science resources that make the teaching of science easier for teachers and more fun for the pupils. Kitchen resources promote collaborative learning, team building, and enterprise in education. It can challenge even the most able students while offering support the weaker pupils. Chemistry teachers must think on their feet. While Chemistry is an exact science, the teaching of Chemistry often requires creativity and improvisation. To make Chemistry concepts comprehensible to students the teachers must employ creative teaching methods and be prepared to respond to queries or explain concepts in a typical manner. Teachers who are adept at improvisation will likely be more successful in imparting Chemistry information to the novice Chemists in their classes (Schreiner, 2012).

The significance of this study is that the findings will give us insights on the effectiveness of kitchen resources in facilitating students' academic achievement and retention in Chemistry, particularly thermochemistry concepts.

Constructivism is a learning theory and epistemology that has influenced much of science education lately. It states that students construct their knowledge of the world through their past experiences. Students do not learn much just by sitting in class listening to the teacher, memorizing repackaged assignments, and spitting out answers. They must talk what they are learning, write about it, relate it to past experiences, and apply it to their daily lives. They must make what they learn part of themselves. Rogers (1969) argues that «much significant learning is acquired by doing» and that learning is facilitated when the student is a responsible participant. Vygotsky's social constructivist theory states that learning takes place in a social context and that in interaction with others (Palinscar, 2005). Students are encouraged to say and do when working with kitchen resources. Teachers who are concerned with students' emotional, social and academic needs have been found to encourage more students' involvement in lessons.

Active learning offers a paradigm for students learning that differs from the traditional lecture method-based model (Johnson et al., 2006). Differences in provision of learning and amount of learning is obvious from Edgar (1969) cone of experience/learning. The cone of learning shows that learners only remember 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they hear and see, 70% of what they say and 90% of what they say and do. The research was conducted within the theoretical context of social constructivist theory and Edgar-Dale's cone of learning experience.

Methodology

The research design was pretest-posttest control group quasi-experimental design with the retention test given two weeks after the posttest. The study was carried out in Calabar Education Zone of Cross River State, Nigeria. The sample consisted of 240 Senior Secondary School II Chemistry students from four schools in four Local Government Areas in Calabar Education Zone, selected using the stratified random and purposive sampling methods. There were 120 students each in the experimental and control groups. The experimental groups were taught using kitchen resources while the control groups were taught using conventional teaching method without kitchen resources. A 60-item five-response option objective test (Chemistry achievement test, CAT) developed by the researcher was used as the pretest, post test and retention test after validation. The CAT items which were drawn to cover all the sub-topics of thermochemistry on a well planned test blue-print were rearranged with its options in pretest, posttest and retention test to have different numbering so as to give a vague impression that the tests were different. The reliability of CAT was estimated to be 0.81. Treatment lasted for a period of six weeks. The first author taught the experimental groups while the normal teachers taught the control groups. The data collected with CAT were analyzed using ANCOVA with pretest as covariate.

Result and Discussion

The result of the analysis in Table 1 showed that students taught Thermochemistry using kitchen resources had a significantly ($F = 1047.381$, $p < .01$) higher mean academic performance (mean = 47.67) in comparison to those taught without kitchen resources (mean = 16.833).

Table 1. Means, standard deviations and summary of analysis of covariance of influence of treatment on Chemistry students' performance in Thermochemistry.

TREATMENT GROUP	N	X	SD
Experimental	120	47.67	9.19
Control	120	16.83	6.40
Total	240	32.25	17.35

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARES	F	SIG LEVEL	PARTIAL ETA SQUARE
Corrected Model	59325.414	2	29662.707	556.811	.000*	.825
Intercept	29235.333	1	29235.333	548.788	.000*	.698
Pretest	2283.748	1	2283.748	42.869	.000*	.153
Treatment	55796.641	1	55796.641	1047.381	.000*	.815
Error	12625.586	237	53.273			
Total	321566.000	240				
Corrected total	71951.000	239				

R-Squared = .825 (adjusted R = .823) F-critical = 3.86 * $P < .05$

In the multiple classification analysis in Table 2, an eta value of .815 was obtained while the R^2 value was .825, indicating that about 82.5% of the variance in students' academic achievement can be explained by the treatment. Similarly, the results in Table 3 showed a significantly ($F = 1468.581$, $p < .01$) higher mean retention score for the experimental group (taught using kitchen resources) that is 47.42 as against the control groups with a mean retention score of 12.07.

Table 2. Summary of multiple classification analysis of Thermochemistry achievement by experimental and control groups.

MEAN =32.399 VARIABLE + CATEGORY	N	UNADJUSTED DEVIATION	ETA	ADJUSTED FOR INDEPENDENT Y COVARIATES DEVIATION	BETA
Treatment					
1	120	15.106	.815	15.27	.943
2	120	-15.106		-15.27	
R^2					.825
R					

Table 3. Means, standard deviations and summary of analysis of covariance of influence of treatment on SS2 Chemistry students' retention level on Thermochemistry.

TREATMENT GROUP	N	x	SD
Experimental	120	47.42	9.28
Control	120	12.07	4.97
Total	240	29.74	19.21

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARES	F	SIG LEVEL	PARTIAL ETA SQUARE
Corrected Model	76244.066	2	38122.033	758.096	.000*	.865
Intercept	27339.571	1	27339.571	543.675	.000*	.696
Pretest	1266.716	1	1266.716	25.190	.000*	.096
Treatment	73849.899	1	73849.899	1468.581	.000*	.816
Error	11917.918	237	50.287			
Total	300458.000	240				
Corrected total	88161.983	239				

R-Squared = .865 (adjusted R = .864) F-critical = 3.86 * $P < .05$

Also, Table 4 eta value indicated in the MCA was .816 while the calculated R^2 value was .865 which means that about 86.5% of the variance in the students' retention scores can be accounted for by the treatment.

Generally, the results indicated that the treatment was effective in differentiating students taught thermochemistry with kitchen resources and those taught thermochemistry without kitchen resources in terms of their academic achievement and retention. This study showed the importance and significant role played by instructional materials (Kitchen resources) on students' achievement and retention in Chemistry. They have positive effect on students' achievement and retention in Chemistry.

Table 4. Summary of multiple classification analysis of Thermochemistry retention achievement by experimental and control groups.

GRAND MEASURE	MEAN = 29.74 VARIABLE + CATEGORY	N	UNADJUSTED DEVIATION	ETA	ADJUSTED FOR INDEPENDENT Y COVARIATES DEVIATION	BETA
Thermochemistry Retention achievement	Treatment					
	1	120	17.68	.861	17.56	.917
	2	120	-17.67		-17.56	
	R ²					.865
	R					.864

Conclusion

The study showed the importance and significant role played by instructional materials (Kitchen resources) on students' achievement, especially in Chemistry. They have positive influence in Chemistry achievement and retention. It was therefore observed that using kitchen resources assisted teachers by making teaching easier and practical. It allowed students to interact better in their lesson.

It made students to use their intellectual ability during the learning and teaching process. It encouraged creativity, bringing learning homewards and often improved and enhanced students' achievement. This is perhaps because a subject like Chemistry requires real objects and activities/experiment that can convert topics that seem imaginary and abstract to real and concrete form to facilitate students' understanding.

References

- Edgar D. (1969). *Audio-visual methods in teaching*, 3rd Ed. Holt, Rinehart and Winston, New York.
- Eshiet I.T. (1996). *Improvisation in Science Teaching-Philosophy and Practice*. Abak Belpot (Nig.) Co.
- Hayward D. (1992). Do it yourself Chemistry for Elementary Schools. *International Newsletter on Chemical Education*, 37 (99), 1-3.
- Helmestine M.A. (2010). *Science experiment from the kitchen*. Available at: <http://chemistry.about.com/b2011/09/17/>
- Ifeakor A.C (2006). The status of resources for effective teaching of chemistry in Nigeria Secondary Schools. 40th Annual conference of STAN, 205-207.
- Ihuarulam A.I. (2008). *Chemistry teachers' perception of availability and utilization of resources for curriculum development in Kano State*. Unpublished M. Ed thesis, University of Kano, Nigeria.
- Ivowi U.M.O. (1999). *Perspective on Education and Science Teaching*. Foremost Educational Services Limited. Abuja.
- Johnson P. (2005). Kitchen chemistry @ tiscali.co.uk
- Johnson D.W., Roger T.J. & Karl A.S. (2006). *Active Learning: Cooperation in the college classroom*, 3rd Ed. Interaction Book Company, Edina MN.

- Nbina J.B. & Obomanu B.J. (2011). Assessment of the effect of problem solving instructional strategies on students' achievement and retention in chemistry with respect to location in rivers State. *World Journal of Education*, 1 (2), 27-79.
- Nkanu M. (2009). *Relationship between Educational Resources and students academic performance in Akwa Ibom State*. Unpublished Doctoral Dissertation, Faculty of education, University of Uyo, Nigeria.
- Okafor P.N. (2000). Difficult concepts in Physics as experienced by senior secondary students in Akwa Ibom State. *Journal of Research Information in Education*, 1 (1), 25-30.
- Opera M.F. (2008). *Utilization of laboratory facilities and students' academic performance*. Unpublished M.Ed thesis, Anambra State University Uli, Anambra State.
- Oriade T.I. 2008. An empirical study of the utilization of instructional materials and laboratory resources in Biology. A paper presented at the 4th Annual Conference of STAN, Bayelsa State.
- Palinscar A. (2005). Social Constructionist perspectives on teaching and learning. In Daniels H. (Ed.). *An Introduction to Vygotsky*. London Routledge
- Rogers C. (1969). *Freedom to learn*. Charles Merrill, Columbs, OH.
- Schreiner E. (2012). *Roles of Improvisation in Chemistry Teaching*.
- Snodgrass J.B. (2001). *From the kitchen to the classroom: Ideas and lessons for the science teachers*. Harper & Row, New York.
- Uche S.C. & Umoren G.U. (1998). *Integrated science teaching: Perspective and approaches*. AAU Vitalis Book Company, Aba.
- Udo E.U. 2006. Availability, Selection and utilization of instructional resources for teaching primary science in Uyo Local Government Education Authority, Akwa Ibom State. 47th Annual Conference of Sciences Teacher's Association of Nigeria.
- West African Examination Council (2010). *Chief Examiner's Report*. WAEC, Lagos.

METEOROLOGY AND CLIMATOLOGY EDUCATION: AN EXPERIENCE WITH YOUNG PEOPLE IN FRIULI VENEZIA GIULIA – ITALY

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Abstract – This work underlines the experience of meteo/climate divulgation at pre-teen and teenager (6-19 years) of Basic, Middle and Secondary school to: investigate the knowledge of Friuli Venezia Giulia particularity in the Italian and European context; discover the interesting meteorological events (remarkable temperature range, abundance of precipitation, type of precipitation, windiness, etc.); learn the aspects and the principal dynamics, the formation and evolution of meteorological phenomena; arise interest for meteorology and climatology in genera; compare with planetary problems, concerning also the global warming, and human influence on the atmosphere; test, with the more interested and capable young people, the instrumental measurement and calibration (elaboration of the collected data, control and validation, plotting); analyse meteorological maps and forecast model; issue a weather forecast.

Keywords: climatology, divulgation, inform, meteorology, practice, peer-education

Introduction

OSMER FVG, Regional Meteorological Observatory is an operational structure of ARPA (Regional Agency for Environmental Protection) whose aim is to provide climatic monitoring and weather forecasts for the Friuli Venezia Giulia region (autonomous region in North-East Italy, with a population of 1.200.000).

The expertise of OSMER are: management of networks of meteorological stations and radar (elaboration, validation and storage of data), research and development in meteo-climate, issue a regional and sub-regional accurate weather forecasts and all support informatics.

Since 1990, OSMER has implemented a meteorological observing system and has investigated over a pattern of meteorological phenomena, typical of this zone, as strong rainfall precipitation, frequent thunderstorms with hail, strong wind Bora over the sea.

The observation, knowledge and the experience acquired, coupled with availability of the GRIB data of the best evolved mathematical meteorological models (as ECMWF, DWD, ALADIN, GFS, etc.), allow to issue accurate local weather forecast. This information is diffused via media, web, e-mail, and traditional ways.

Conferences, lessons, courses and guided visits contribute to divulgation of local meteorological culture in favour of the regional population, that can increase benefit from this formation and information.

During the divulgation activity the work is for all population, with segmentation activity for age and sector (ski-teacher, ski-rescuer and ski-patroller, alpinist, farmer, sailor, university of third age).

The experience of divulgation in this work looks at pre-teen and teenager (6-19 years) of Basic, Middle and Secondary school and at the teachers.

Methodology

What should be meant as “meteorological divulgation”?

All the chances (conferences, lessons, courses and guided tours) that allow to make a proposal of diffusion, comprehensible and adapted for each level of the population, are a dialog over:

- principles and main phenomena of meteorology and climatology, general and local;
- activity, technology and operational practice of a meteorological office;
- meteorological literature (books, publications, reviews, quarterlies) about discoveries and scientific refreshers;
- information sources of meteo/climate (Radio-TV program, Teletext, Internet);
- institutes and other offices that operate in meteo/climate

We think that at the source of the divulgation, we feel advisable two beautiful sentences, the first of I.A. Comenius «Teach everything to everyone entirely» and the second of C. Lubich: «All that is not given or donated to young generation, is lost. Give always; give a smile, an understanding, a pardon, listening; our intelligence, our will, our availability; our experiences, capabilities. Give: this is the word that can't give us respite».

It's important too to reflect about the expression of emotion during the non-verbal communication, that has a strong influence on the quality of an intervention of divulgation.

We consider as important the necessity to intervene using a competent and appropriate language, a mirror of the depth of the knowledge and self-internalization, while keeping, in every situation of relationship with the public, a friendly style and overall comprehensibility for the majority of the people, to make everyone aware with liking and completeness.

Now we mention some old sentences, to feel the true spirit of the divulgation.

According to the rhetor Vittorino (IV sec.), there are 3 causes of darkness of the language: *vel rei magnitudo, vel doctoris imperitia, vel audientis duritia*. After this sentence A. Rosmini added the malice.

Hans Georg Gadamer says: «Who speaks a language that nobody understands, doesn't speak. Indeed to speak would mean speaking to somebody. The word should strike the mark; by the way this doesn't mean only that it represents to oneself the thing thought, but that this word puts the thing in front of the eyes of the one I am speaking to».

Karl R. Popper says that the research of truth is possible only if one speaks clearly and simply and when technicality and unnecessary complication are avoided: «Who is not able to speak in a simple and clear way must be silent and continue to work up till the moment in which he will be able to speak clearly».

Gottfried Wilhelm Leibniz expressed in this way about the dark language: «There are, rarely, excusable and absolutely laudable darkness: in case someone makes an enigmatical declaration and the enigma is opportune: a type of obscurity shall be allowed, by the way it is necessary that it hides something that is worth to be discovered, and that the enigma shall be decipherable».

M. Baldini, philosopher of the language, suggests that it is better not to fall in the temptation to create a special language for specialists in the moment when it turns to the public, always remembering the fundamental social agreement: to make everyone aware starting from the middle social level. It is better not to use a too much scientific language, meteorological language, etc.

The importance of the style of the approach to the subject, especially with the teen-agers, is founded over the methodology polynomials «to be, to know, to know how to do, to know how to make do», pivot of the present education, above all in the scientific divulgation.

We consider «to know how to make do» as a capacity to arrange, for the kids, plays and metaphors, handy to represent some complex dynamics, for the teen-agers, over the metaphors, suitable exercitations, above all with meteorological instruments (i.e. correct surveys and calibration) and through computer exercitations.

The acknowledgement of the beginnings and the dynamics shall occur in a figured way, socially connoted (coloured little balls, other simulations), according to the suggestion of the educational of the science and the psycho-pedagogy research for the assimilation of the concepts.

During the chances of educational the science with teen-agers, the approach of “learning by making” emerges as a fundamental way, that means schooling by concrete experimentation, touching the instruments and materials, exercitations to build simple meteorological instruments, (effective for the comprehension of the phenomenon).

Goals for the meteorological divulgation

- *identify* the fundamental concepts of meteorology and climatology, starting from several meteorology elements: temperature, humidity, air pressure, wind, precipitation;
- *verify* the level of knowledge of meteorological phenomenon: high an low air pressure, warm and cold fronts, stau and foehn, thunderstorms, breeze, prevailing wind; extend and complete the identification of itself;
- *grasp* with major scientific deepness the aspects and the principal dynamics, the formation and evolution of meteorological phenomenon;
- *know and understand* the technologies and the functioning of principal observation and recording meteorological instruments;
- *investigate* the knowledge of Friuli Venezia Giulia land geography’s, in the Italian and European context, the countries with peculiar characteristics whose fingerprints are also in a special climate and in the development of interesting meteorological events: remarkable temperature range, abundance of precipitation, type of precipitation, windiness, etc.
- *arise interest* for meteorology and climatology in general, confront with planetary problems, concerning also the global warming, and human influence on the atmosphere;
- *explain* how the activity of weather forecast concretes is carried on, as a general job, but also in a local context, involving the teen-agers in the proper way, even through the use of OSMER operational instruments;
- *inform* about activity, studies and researches that are actually developed in OSMER, ARPA, operative agencies for the public, but also about other subjects that are involved in meteo/climate;

- *make the people aware* about a critical essay of meteo/climate informative sources, to start up a better scientific consciousness, that allows to extricate oneself in the outline of meteorological issues;
- *test*, with the more interested and capable people, the instrumental measurement and calibration (elaboration of the collected data, control and validation, plotting), the analysis of meteorological maps and forecast models, the elaboration of weather forecast.

Results and actions

1. *The project: "Touch the air not with the hands, but with the eyes of reason"*

Since 1990, OSMER has tried to bring (as well as meteorological observation and weather forecast), a small contribution to increase the meteorological culture in the schools, with a lot of lessons, guided tours, to spread the knowledge, with all type of schools, kids and young, even with the idea to expose the knowledge with appropriate language and methods, even to promote meetings with the teachers about such topics.

The project "Touch the air" since 2002 has tried to grow a box, for a more organic and appropriate work, to introduce a series of lectures, lessons and activity, from an idea of prof. M. Vellarde (past president of CISM of Udine – International Centre for Mechanical Sciences), sponsored by a group of Clubs Services, single persons of such Clubs, and implemented from a group of teacher on volunteer basis from public and private schools of Friuli Venezia Giulia.

Goals of this project:

- to make the teen-agers approach the science of the phenomena, to increase the scientific knowledge and to understand causes and effects;
- to introduce the meteorological problems of the region, through the research and the direct knowledge by the teen-agers (that will be the future heads in the society);
- to involve the youth in group-working, to improve the autonomy and the responsibility;
- to increase the sensibility for concreteness and practicality;
- to connect the information, the elaboration and the discoveries, with the aim that other young people can be interested in this field and become enthusiastic;
- to privilege the learning of the use of personal computer to collect the meteorological data and to the communication;
- to exploit the better time during the age of development for the scientific learning (11-14 years old);

The project started with graduality and patience, supported by a pattern of Clubs Service, contacting the headmasters of secondary schools interested in the project for the determination of the teachers.

Together with the purpose of involving, a series of lessons and meetings has been organized, and investigation about meteo/climate focused to the teachers, and after, together with the teachers, actions to individualize the work.

An idea to start with a methodical collecting of the principal meteorological elements (min e max temperature, precipitation, wind speed and direction, air pressure, relative

humidity) by the teen-agers has been implemented, by the use of simple mechanic instruments, located inside traditional instrument shelters (white wood, made by other groups of young people of the occupational school)

Together with the first approach to the meteorological data, theoretic and practical lessons have been done to improve elements of meteo/clima for each class, and to digitalize data in tabulations, to schedule an open-web site, where every group shall insert information and especially their own experience.

So, with the implication of all the teachers (not only on science topics), a big series of activity started, that have involved the students in all topics:

- in the scientific teaching, with investigation of physics;
- in mathematics and statistics, starting from observed data;
- in technology with research about the instruments and in the preparation of other simple instruments, built by the students;
- in Italian literature connected to the meteo/climate events, and in the use of terms;
- in other European languages and literatures, to observe the differences with respect to the Italian language;
- in the history of music;
- in the history of theatre;
- in the history of arts, especially painting;
- in the production of meteo/climate video-clip.

At the end of this first step, after 2 years, a big meeting has been organized, in which all the results have been exhibited. Such “event” has involved more than 600 students during a day, in an auditorium inside Udine town.

During the following years, it has been planned to further enrich the purpose, suggesting to the involved class, in addition to the continuation of meteo observation and the production of material about meteo/clima with the publication on the site web, an experience with the show “EnergEticamente – EnergEthically”, made from colleagues of LaRea FVG (Laboratory for environment education), belonging to ARPA FVG.

This show has the energy as main topic, and has been proposed, since 2004, in a lot of Italian cities. It consist of a series of 20 interactive exhibits, that allow of observe and understand natural and physics phenomena that occur during the daily life. During the planning of the exhibits a mention is due to the primary resource of energy: the sun.

The route “EnergEthically” covers various aspects of the sun’s energy in 5 groups of exhibit:

- the greenhouse effect
- the phenomenon of convective flows
- About electric energy:
- how is it generated
- how it creates electromagnetic fields
- how to transform the solar power

The purpose of “EnergEthically” is to make a consideration about how could be possible to decrease the waste of energy by selecting the instruments and the materials more

suitable to improve the energetic efficiency. Finally it is possible to take in account the use of alternative sources of energy with respect to the fossil fuels (i.e. biogas, hydrogen, wind source).

“EnergyEthically” may be a chance to think about our lifestyle, about living the space and about our system of mobility, in a way to understand which type of ecologic mark we leave in the world with our behaviour. Furthermore, this enterprise may offer a chance about more ethic and sustainable energetic scenarios.

In order to prepare the pre-teens (6-11) and teen-agers (12-17) at this show, we offer 14/15 and 17/18 years old a chance as tutors, with the methodology and experience of peer-tutoring, called so peer-education or teaching.

This methodology identifies an educational strategy that activates a spontaneous transfer of knowledge, of emotion and of experiences, from some older student to a group of younger, starting a global process of communication, characterized by an intense experience and a strong attitude of research of authenticity and concord in developing intense transferral moment.

During the stage of training of the student-tutor, we face these topics:

- investigation of physics: temperature, relative humidity, air pressure, wind, precipitation, notes on fundamental laws of physics and fluid dynamics;
- investigation about the concepts treated inside the exhibit of the show: heat conservation and exchange, photovoltaic, functioning of the dynamo, energetic performance, exploitation of renewable resources;
- meteorology and climatology, general and local, the hypothesis, cause and effect of the global warming, the greenhouse effect;

During the “event”, separate classes of students have been “kept in foster” from a small group (2 o 3) of student tutor, that accompany and illustrate the exhibits, making experimentation and “touching” the kits, so obtaining a strong implication.

It’s remarkable the follow-up of people, parents of the students, media and representatives of other schools and cities, that use to ask for the repetition of the experience.

Together with the involved class a spontaneous group of students has been created that have met again, to improve the studies about climate change, alternative energy, projecting of other kits and instruments, improvement of the divulgation of such themes and furthermore the propagation of this experience.

2. Production of a series of meteo-climatological videoclips

The aim of this work is to begin to produce a series of thematic video-clip about educational meteorology and climatology in Friuli Venezia Giulia. The first video-clip is going to be finished now with the title “The voices of the rain”, with the aim to increase the knowledge of the rain in this area of the Alps, that presents the maximum of yearly precipitation in Italy.

This video clip, supported by regional funds for the minority languages, presents the physical causes and effects of heavy rain over this land, the climatic characteristics of different areas (coastal zone, plain, hills, pre-alpine and alpine zones), the behavior of the people during the heavy rain events, the popular forecast traditions and case-studies of historical and recent flash-flood events.

The video clip is in the 4 natural languages of the people of this land (Italian, Slovenian, German, Friulian) with a series of interviews (the voices) in typical towns. There is an insert about an educational training for young people to understand instrumental basic concepts of rainfall measure, explanation of the forecaster's job during a day in the meteorological regional observatory (OSMER), and the climatological description of the land.

Conclusions

The satisfaction of this divulgation offer is very good, supported by an increasing request from families, teachers and schools and by a big interest established by Mass-media, with a lot newspaper articles, radio interviews and especially TV services.

We can try to quantify the movement generated of this Experience of divulgation (in this small land of Italy with 1.235.000 inhabitants) per year:

Type of people	n.
Children (3-6 years old)	200
Pre-teens (6-11 years old)	500
Teen-agers (11-19 years old)	1000
Teachers	50
Adults	300

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References

- Baldini M. (1989). *Parlar chiaro, parlare oscuro*. Laterza, Bari.
- Gadamer H.G. (1972). *Verità e metodo*. Fabbri, Milano.
- Leibniz G.W. (2000). *Scritti filosofici*. Mugnai M. (Ed.), UTET, Torino.
- Lubich C. (2006). *La dottrina spirituale*. Città nuova, Roma.
- Rosmini A. (1975). *Il linguaggio teologico*, in *Opere teologiche*. Città Nuova, Roma.

THE ROLE OF *DROSOPHILA* IN TEACHING LIFE SCIENCES

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Abstract – Model organisms do play an important role in conveying biological concepts. They are more amenable to asking certain questions due to their simplicity of structure and features. In order to explore the advantages of using model organisms in classrooms, we will examine their desirable attributes, why certain organisms have been chosen as model organisms for teaching, the advantages of using model organisms in teaching, and examples of model organisms popular in biology instruction. Many model organisms have been used in the classroom.

The fruit fly, *Drosophila melanogaster*, has been the most popular eukaryotic organism used in classrooms. It is a small fruit fly about 3mm long, similar to the ones you see attracted to your bananas and other fruit. It has short life cycle of two weeks, making it possible to study numerous generations in a short period. It is easy to culture and inexpensive to house large numbers. Its size is amenable for cultivation in school laboratories. Also, it is large enough that many attributes can be seen with the naked eye or under low-power magnification. Moreover, it has a very long history in biological research and there are many useful tools to facilitate genetic study. It was recognized by the award of the Nobel prize in Physiology or Medicine to Thomas Hunt Morgan in 1933, to Hermann Muller in 1946 and to Ed Lewis, Christiane Nusslein-Volhard and Eric Wieschaus in 1995.

The use of *Drosophila* is a powerful tool also in teaching the Life Sciences. In fact it allows the observation of sexual dimorphism, of mutants and of the life cycle. Moreover it permits the realization of crosses aimed to demonstration of sexual linked characters and crosses aimed to establish if a mutation is conferred by a dominant or a recessive gene.

Keywords: conveying biological concepts, *Drosophila Melanogaster*, life cycle, teaching Life Sciences

COMMUNICATING SCIENCE TO HIGH SCHOOL PUPILS BY VIDEO PRODUCTION: LESSONS LEARNED

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Abstract – The Collaborative Research Centre 754 (SFB 754) at GEOMAR in Kiel, Germany is an interdisciplinary research programme, which investigates the threats posed by ocean de-oxygenation and how this is coupled with climate change and the nutrient balance in the tropical oceans. The outreach component of SFB 754 has the task of producing videos with and for school pupils, in which different aspects of the science of the SFB are explained and introduced in a short and entertaining fashion. The goal is to attract pupils to sciences, both by the active involvement in the video production and by the consumption of the videos made by other pupils. So far more than 30 video clips were published on a dedicated website for viewing and download. The process of video production is enjoyable for all parties involved, but it is also time consuming and entails considerably more work for students and teachers, than normal lessons in class. As a result, the project now concentrates on dedicated summer schools and after-school activities as a platform for video production.

Keywords: ocean science, outreach, oxygen minimum zones, science communication, video clips

Introduction

The focus of the Collaborative Research Centre 754 (SFB 754) at GEOMAR in Kiel, Germany is the investigation of oxygen minimum zones in the world oceans because of the recently discovered potential threat of ocean de-oxygenation. Possibly as a consequence of global warming of the atmosphere (Bertrand *et al.*, 2010), oxygen concentrations in large areas of the Pacific, Atlantic and Indian oceans (Stramma *et al.*, 2010) are decreasing, with implications not only for marine organisms but also for entire marine ecosystems. Clearly, this kind of cutting-edge research cannot be reflected in a high school curriculum but SFB 754 scientists consider it their moral obligation to make pupils – as future decision makers – aware of this problem.

The processes occurring in oxygen minimum zones are not straightforward, and simplifying the science for high school pupils is already quite a remarkable task. In addition, many pupils perceive science itself as a difficult subject. Thus, generating interest for a complex topic seemed to require a different approach. To meet this challenge, the outreach team of SFB 754 decided to focus on web-based video-clips as an attractive medium, which is fun and to which pupils can easily relate because they use it in their daily lives. However, while many pupils encounter web-videos mainly passively as entertainment or part of social networking, here, they were to be involved as the actual producers.

The following text describes this effort to introduce science to high school pupils by encouraging them to produce videos on specific topics of ocean de-oxygenation for fellow pupils. With this approach, our team attempts to motivate not only pupils who are already

interested in science but also pupils who have a negative attitude towards the natural sciences. We include here an assessment of this method with regard to our experience and our recommendations for groups who would like to use this method for their own outreach efforts.

Methodology

The science and video courses offered by the SFB 754's outreach team were conducted in different frameworks:

Table 1. Types of courses where this approach was tested.

COURSE TYPE	NUMBER OF PUPILS	FREQUENCY/DURATION	DESCRIPTION
Project week	Whole class (25-30)	1-2 weeks	integrated in a subject during the school year; participation compulsory
Practicum/Internships	individual	1-2 weeks	done at the research institute for job training; participation compulsory or voluntary
After-school activity	4-8	1-2 hrs./week for up to one school year	after classes, not graded; participation voluntary
Regular class	25-30	Weekly; max. 1.5 hrs.	some parts of the project done as homework; participation compulsory
Summer camps	12	2 weeks	during the summer vacation; participation voluntary; not graded

In all these courses the following methodology was used:

Conveying the science. The very first step in a course towards a video on science is to get the facts right. The contents of the video should be scientifically sound and authentic. To achieve this in their school or at the research centre, the pupils are brought in contact with scientists who are doing research on a specific topic. In a presentation, the pupils learn about the most recent research findings and in some cases they get to visit the laboratory of the scientist.

The lectures are followed up by experiments, which help the pupils visualise the phenomenon described in the presentation. In many cases the pupils are asked to do further literature research on the topic to strengthen their background knowledge.

Introduction to video production. After the scientific part of a course, a member of the SFB outreach team experienced in video production introduces the pupils to the use of the camera equipment, scene composition, sounds, video editing and post-production. All equipment used for shooting and editing the clips is provided by the research centre. To familiarise the pupils with the video equipment they are asked to produce a 1-minute test-video clip on a prescribed theme.



Figure 1. Experiments are performed to introduce the pupils to the science that they will portray in their videos.

The struggle for a concept. The most difficult part in most video productions is the creation of a storyboard. First, the pupils are asked to decide a small specific aspect of the science topic, which they would want to feature in their video. Next, they have to decide what kind of video they would like to produce. It should be noted that, although documentaries and interviews are the most obvious and also easiest kinds of videos to produce on science, they are not encouraged because the media are already flooded with these formats. In addition, many young people only find documentaries interesting if they feature spectacular footage, which is hard to produce in the context of a school video. Instead, the pupils have to be original to attract their fellow viewers' interest. Thus, all film genres, from thrillers to love stories, are allowed as “packaging” for the scientific message. This, however, involves the writing of a storyboard for which several basic points have to be kept in mind:

- the video should appeal to young people like the pupils themselves,
- it should be scientifically correct,
- it should be short, if possible not longer than 5 minutes, and
- the storyboard should sketch a well-rounded story before they start filming.

Shooting and editing the film. This is usually the fun part of a course. The pupils each assume a specific function in the making of the film. They could be cameramen or -women, sound directors, lighting experts, directors and actors. In this part of the course, even



Figure 2. While shooting the video, the pupils assume different roles as actors, cameramen or sound engineers.

pupils, who are usually not inclined towards the sciences, take an active role in the project. The pupils are given few limits to their creativity and much room for improvisation. After the shooting, the editing of the film is usually assigned to one or two pupils, usually those who have previous experience in film editing. The other pupils are responsible for producing sound effects, choosing license-free music from the internet or making their own background music.

Postproduction. Once finished by the pupils, the raw video is usually given some “finishing touches” by the SFB 754 outreach team. This includes adjusting the sound quality, sometimes improving the picture quality and attaching the credits and copyrights. The finished video is uploaded to the Internet under <https://sfb-outreach.geomar.de> both for viewing and download.

Evaluation. At the end of each course, the pupils are given questionnaires with around 30 items to evaluate the course. A more detailed description of the questionnaire can be found elsewhere (Dengg *et al.*, 2013). This evaluation, is not administered for scientific purposes, but intended as a self-evaluation for improving the courses.

Results and discussion

So far, SFB Outreach has published more than 30 videos representing different film genres. At the start of the project, the pupils were not particularly bold and adopted only familiar standard formats like children’s programs and interviews. Later videos were more varied: thrillers were popular, spoofs, fairy tales, stop motion films, love stories, etc. As expected, the pupils found producing videos fun and they were not deterred by having to communicate a science topic. In fact the majority like video as a medium for learning and presenting science (Figure 3)

The main problem encountered is the integration of this approach in to normal classroom lessons. Setting up and dismantling the equipment and props is quite time

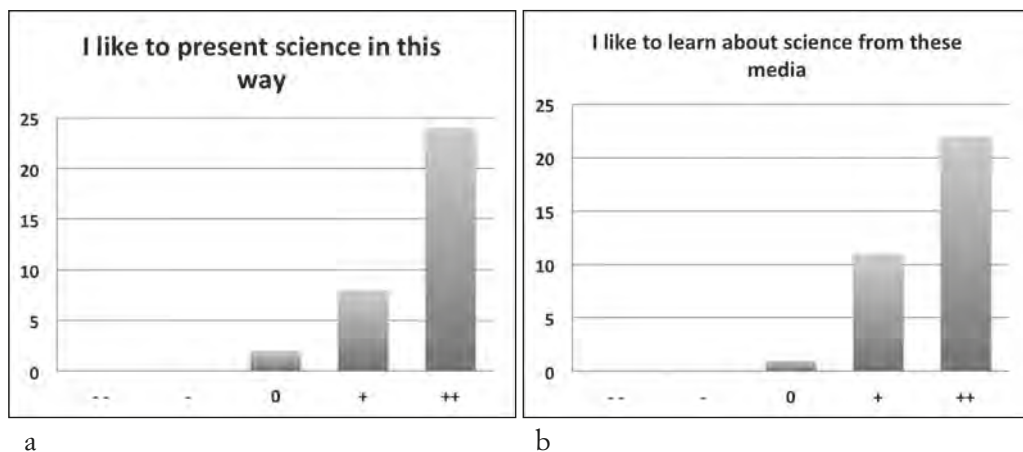


Figure 3. Results of the evaluation for the 4 summer camps offered for pupils. The majority of the pupils who enrolled liked learning (a) and presenting (b) science through videos. Legend: - - strongly disagree; - disagree; 0 undecided; + agree; + + strongly agree, $n = 34$ (summer schools)

consuming and this deters teachers from using this type of video production for conveying science to their pupils. This is also true even if they have assistance from the SFB outreach team. On the other hand, teachers report that they have used the completed videos in some of their classes to introduce a new science topic and provide context.

Some of the courses were offered as two-week projects in the school, where the pupils were able to continue the work even after school hours. This was not too popular with the pupils, however: Although they voluntarily invested more time on their videos, they still perceived this as additional homework. Even if they enjoyed filming, they complained about the extra hours invested in the project, which they felt were not adequately considered in the final grading of their product.

The best conditions for this kind of work turned out to be the summer school courses during vacation time. Here the pupils came voluntarily and were free of other school-related responsibilities like writing reports, studying for exams or preparing presentations. The pupils were free to enjoy the course because it was not graded, and they could let their creativity run free.

During the film editing stage, a frequent problem is that only one or two pupils from a group of four or five can be involved in the task. This may leave the rest of the group without any real tasks, unless they are producing sound effects and choosing the music for the film. Recently, we experimented with asking them to write a short document or prepare a poster about the contents of their video. These are then posted in the SFB-outreach website or offered as supplementary teaching material for download.

From the feedback in our evaluations we would conclude that in general the pupils did develop a keener interest in science after a course (Figure 4). This is particularly remarkable in that this evaluation was done with summer school pupils who in a different item of the evaluation already indicated a very high level of interest for sciences to begin with. They enrolled voluntarily and with great motivation for a very intense course during their summer vacation, and apparently the majority left with their interest in sciences confirmed or even strengthened.

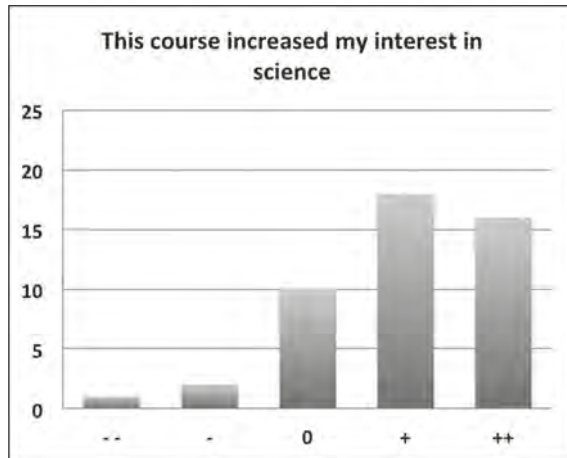


Figure 4. Response of summer school pupils to questionnaire item “This course increased my interest in sciences”.

Legend: - - strongly disagree; - disagree; 0 undecided; + agree; + + strongly agree, n= 49 (summer schools)

Unfortunately, this pre-selection of pupils biases our analysis, as Figure 5 depicts: the majority of the participants in the summer schools give their grades in the natural sciences as “good” or “very good”. Thus, we are not able to deduce if pupils with less than average grades display an enhanced interest in sciences after the course.

Conclusions

Pupils generally welcome the idea of producing videos as a method of presenting science. They find it a fun and an entertaining way to learn science. During the development

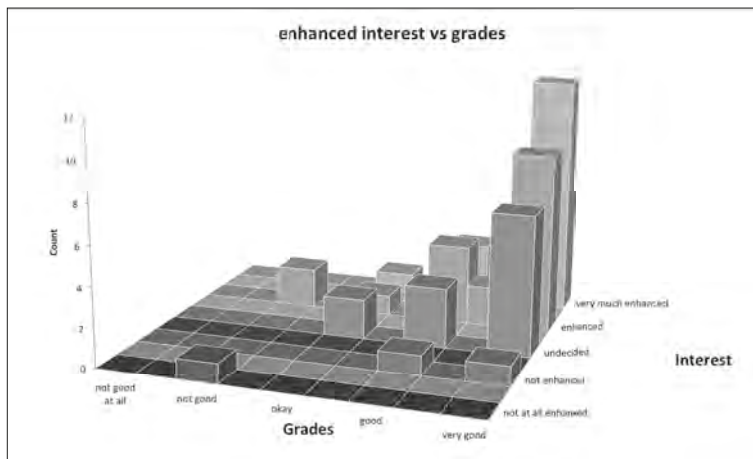


Figure 5. Frequency distribution of pupils in the summer schools as a function of their own perception of their school grades in sciences and the enhancement of interest in sciences after the course (n= 49).

of the story line for their films, they get to know a specific aspect of a bigger science topic in sufficient depth to be able to explain it to viewers. Video production also develops social competences among pupils, teaching them to be team players by performing specific tasks during the process. For pupils, video production is a satisfying project particularly because they obtain a concrete product they can show to friends and relatives.

However, there are several drawbacks to this form of introducing new science concepts to pupils. First and foremost is the time and effort involved in video production. This kind of activity is very difficult to realise in a normal classroom situation, where class hours are limited. Furthermore, a dedicated place is required, where the pupils can leave the equipment set-up until the end of the shooting, thus reducing the time for the installation and dismantling of cameras, lights and props. For teachers without outside help, video production can involve considerable costs and additional work if the pupils do not have experience in making films. However, although it was originally planned in this project to train teachers in video production (Dengg and Wilms, 2012), later experience has shown that many older pupils have at least some experience in filmmaking and can work independently, needing a minimum of supervision.

We recommend video production as a nice way of teaching science to pupils if time, space and equipment are available. Our SFB outreach team is now offering this activity exclusively in summer schools or school projects lasting at least 2 weeks, where the first week concentrates on the science and the second week on video production. Unlike during regular school when the pupils have to study for their other subjects, in summer schools they can concentrate on the subject matter and enjoy themselves at the same time.

Acknowledgements

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References

- Bertrand A. Ballon M. & Chaigneau A. (2010). Acoustic Observation of Living Organisms Reveals the Upper Limit of the Oxygen Minimum Zone. *PLoS ONE*, 5 (4), e10330, doi: 10.1371/journal.pone.0010330
- Stramma L. *et al.* (2010). Ocean oxygen minima expansion and their biological impacts. *Deep Sea Research I*. doi:10.1016/j.dsr.2010.01.005.
- Dengg J., Soria-Dengg S. & Tiemann S. (2013). Marine geosciences from a different perspective: production of „edutainment“ video-clips by pupils and researchers. In Tong, V. (Ed.). *Geoscience Research and Outreach: Schools and Public Engagement. Innovations in Science Education and Technology 21*. Springer. (In press)
- Dengg J. & Wilms M. (2012). SFB Outreach – Schülervideos zu Meereswissenschaften. In Dernbach B., Kleinert C. & Münder H. (Eds). *Handbuch Wissenschaftskommunikation*. (pp. 191-196). Springer VS Verlag für Sozialwissenschaften, Wiesbaden, Germany. ISBN 978-3-531-17632-1.

GAMIFICATION IN EDUCATION: HINTS AND EXAMPLES

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Abstract – This paper is devoted to using of gamification approach in technical studies. All course is organized as competition between few teams of students, which have the same tasks, the same inputs but because of team work can provide different level of results. In other case course is very close to practice, so obtained knowledge can help to get future job easier. Authors also proposed using of Google services as communication medium between teacher and students.

Keywords: course, gamification, Google services, motivation, testing

Introduction

The decrease in interest in engineering studies is a phenomenon widely observed in Europe and also in Ukraine. The decrease in the number of students in technical and pure sciences (below the 10% of total number of students) happened in the majority of European countries but not in China or India, where every year there are hundreds of thousands of graduates with engineering diplomas.

Other side of the problem is that last year students have low motivation during studying courses which are not close to the practice. So motivation increasing and interest rising to technical studies is very important and actual task and can be solved using gamification approach.

Methodology

Main Approach

To answer question about motivation first we've asked students why they are not interested in some subjects and got answer was very disappointing for us. The main point was: "Your lectures are boring and not interesting". And second reason: courses are not close to practice and it is difficult to understand how useful such knowledge can be in future.

Thus after brainstorming sessions and comparing education experience from industry completely new course "Testing of Program Systems" was developed. Such approach first time was used in CAD department on Lviv Polytechnic National University for 5 year students. New course includes a lot of theoretical information concerning methods and methodologies of testing and also about software development lifecycle. To increase interest to such course following solution were proposed: we will use project simulation game and will try to teach about testing during whole software lifecycle. Now question is 'How?'

Main idea was to change classical approach from lecture -> practice to modern one workshop -> game. And of course include fun part to all learning lifecycle as t-shirts,

cookies, score points and prizes at the end. So following basic topics were selected:

1. Software development lifecycle.
2. Software Testing process
3. Test planning
4. Test methodologies
5. Testing techniques
6. Risk management
7. Team communication

Then group of students was divided for teams of 4-5 persons each. In general group consists of 12-15 people so finally we have 2-3 teams and performing of competitions is not complicated. Each team has team leader who is changed every week to make everyone feel what is team work and responsibility. Assignments also were divided in two kinds: individual and team. This case stimulates students to work not only during the classes but also after them. All communication between students and teachers is performed using Google Applications (Google Sites, Google Docs, Google Mail and Google Calendar). Every team has own site and also site of the course where all related information is stored and can be downloaded at any time.

For testing purposes special application was developed. Application was developed by students of 3rd year as semester assignment, it has few builds and final release – so testing process can be shown from early beginning till the end with all details which appear during testing.

On fig. 1 example of the Google site for one of the team is presented, where all contact information is collected. Also inbox and outbox is added to simulate communication with virtual customer.

Testing Esomiate Boot Camp #1 Archive, May-July 2011. >

YMKA Team's Home

Testing documentation
Checklists
MOM
Weekly report
Test cases
Team members:

Member	Role	E-mail	Skype	Phone
Anton Shevchenko	Team Lead	Shevchenkoja@gmail.com	shevchenkoja	+380935749383
Konstantin Tsiandiev	Tester	konstantin_tsiandiev@epam.com	konstantin_tis	+380964581772
Maria Kovall	Tester	Maria_Kovall@epam.com	mary_kovall	+380937172269
Yuliya Branytska	Tester	Yuliya_Branytska@epam.com	br_yulia	+380678106673
Yuliya Zalzna	Tester	Yuliya_Zalzna@epam.com	zalzna.yuliya	+380965216144
Yuriy Osadchuk	Tester	Yuriy_Osadchuk@epam.com	osadchuk.yuriy	+380939744713

Inbox

RE: EPM-LNCH Reports Design' Requirements Analysis From: Rosin CreeTo: Maria KovallPriority: NormalHello Rosin, Here is some clarifications: 1a. "Refresh" button just refreshes page and picked-up last data from db. It's focused ...
Posted Jun 7, 2011, 8:10 AM by Unknown user

RE: Requirements Analysis "EPM-LNCH Logging system" From: Rosin CreeTo: Yuliya ZalznaPriority: NormalHi Yuliya, First of all - good catch! According to the questions: 2.1. Ability to manage users is for System Administrator users ...
Posted Jun 6, 2011, 3:46 AM by Unknown user

RE: Lack of descriptions in the requirements From: Rosin CreeTo: Konstantin TsiandievPriority: NormalHi Konstantin, It's great that you find real gap in requirement doc. I've already added this item to my training lesson ...
Posted Jun 2, 2011, 1:56 AM by Unknown user

New portion of functional requirements From: Rosin CreeTo: YMKA TeamPriority: NormalTeam, Glad to inform you that there are set of new requirement documents uploaded to "Test application documents" section here: <https://sites> ...
Posted May 23, 2011, 1:02 AM by Unknown user

RE: Smoke test checklist From: Rosin Cree To: Yuliya ZalznaCC: Rebecca Bischo Priority: Normal Yuliya, I've reviewed your checklist. I think we'll have to extend it also. Few comments on the ...

Outbox

EPM-LNCH Functional Design requirements analysis From: Yuliya BranytskaTo: Rosin CreePriority: NormalHello Rosin, After "EPM-LNCH Functional Design" (Module dsh dictionary editing: requirements analysis) I have discovered several issues: **1) 1.2. Database** ...
Posted Jun 8, 2011, 1:44 AM by Unknown user

Team's Roles rotation From: Yuriy OsadchukTo: Rosin CreeCC: Rebecca Bischo Priority: Important Hello! We have some news for you. There was a rotation of roles made in YMKA Team according to ...
Posted Jun 9, 2011, 2:15 AM by Unknown user

RE: Requirements Analysis "EPM-LNCH Logging system" From: Yuliya Zalzna To: Rosin CreePriority: Normal Dear Rosin In reply to your email here are some clarification of items: "Log events will be written for client connection, logging" ...
Posted Jun 7, 2011, 1:08 AM by Unknown user

"EPM-LNCH Reports Design' Requirements Analysis From: Maria Kovall To: Rosin CreePriority: Normal Hello Rosin, After "EPM-LNCH Reports Design" (requirements analysis) I have found a few issues: **1) 2.4. Relations Report** by Vendor ...
Posted Jun 6, 2011, 3:40 AM by Unknown user

Requirements Analysis "EPM-LNCH Logging system" From: Yuliya Zalzna To: Rosin CreePriority: Normal Dear Rosin Could you give me more information about: "EPM-LNCH Logging system": 2. General description + "Logging to files can be turned" ...

Figure 1. Google site example

Conclusions

Results which were obtained: after first try this spring student's feedbacks shown that they are really motivated to attend classes because it was unusual and interesting. Last year students become more motivated and semester grades are higher than in general case. One more thing – course is very close to real work in modern IT companies so they got familiar with future work already at university and can decide which IT direction can be used in future, means that not only programmers are needed in the market.

From teacher's point of view we understood that have chosen right direction in teaching approach but of course it takes a lot of time to prepare such syllabus. Also approach is very flexible and can be applied to any IT course.

References

Кapp, К.М. (2012). *The gamification of learning and instruction: game-based methods and strategies for training and education*. John Wiley & Sons, Inc. 336 p.

Ковалюк, Т., Єфименко, О. Про розвиток, ІТ-освіти України // Вісник НУ «Львівська політехніка» Комп'ютерні науки та інформаційні технології, Львів, 2011, – С. 293-297.

Available at: <http://www.google.com/apps/intl/en/edu/> – google apps for education.

COMPARISON OF FOUR BRANDS OF CULTURE MEDIUM USED IN THE VALUATION OF THE TOTAL MICROBIC COUNT

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Abstract – This project is part of a path in science education who wants to touch the most scientific topics and wanted to unite the world of high school with that of the Quality Control in manufacturing industries (pharmaceutical, food and cosmetic).

In the last years the microbial quality control regulations are substantially changed. Initially they have been focused especially on growth promotion test on culture media and validation of microbial methods.

These tests have introduced a new concept of microbial laboratory self-control, or rather micro-organisms management as reference standard.

The quality of a culture medium, in fact, is determinative in order to detect any microbial contamination, or to determinate microbial count.

The certainty of the results of analysis, is directly in relationship with the effectiveness of the media in question.

This effectiveness is evaluated by performing a growth promotion test on every batches, ready to use or prepared from dehydrated powder. The quality of a media is represented not only by a good sterilization but mostly by the quality of the raw material.

This work was carried out with the third and fourth classes of the Technical Ginori Conti in Florence with Biological Sanitary address. the purpose of this study is to compare four brands of commercially available culture media using European Pharmacopoeia requirements. the result of a growth does not come from the range 50-200% considering 100% the standardized inoculum. The name of the four brands of culture medium analyzed are omitted: our target is to raise awareness all the companies where the growth promotion test is not required about the risks of use of culture media with a low quality.

The choice of a media must not only be based on the costs, but firstly to the correspondence of the same quality requirements.

All four brands of culture medium have the same ingredients in the same concentration. The test have been performed using the strains required from Pharmacopoeia (*Aspergillus brasiliensis* ATCC 16404, *Candida albicans* ATCC 10231, *Bacillus subtilis* ATCC 6633, *Escherichia coli* ATCC 8739, *Pseudomonas aeruginosa* ATCC 9027, *Staphylococcus aureus* ATCC 6538). The recovery have been obtained inside the range of conformity in three of four brands. Instead one brand shows a low value from 9% compared to 100% theoretical.

The use of culture media with a low recovery could be a risk in the microbiological analysis because it underestimates the total microbial counts. The use of this media, for instance, in the food or cosmetic industries could lead to a risk to costumers health.

The results obtained from the experiments have led an active discussion among students

regarding the use of non-conforming culture medium and the relative risks. All the activities has been set having as its purpose the realization of a scientific publication. This has led to a great participation from the students who have worked with great seriousness and professionalism. The successfull of this study was therefore the union of three realities often divided: seven classes of students (world of high school) having as its purpose the creation of a scientific report (world of University) performing tests like the pharmaceutical Quality Control department (world of work).

We thank all the students and teachers who participated proactively to perform the work with passion and interest.

ACTIVE LEARNING SPACES IN SCHOOLS AND HIGHER EDUCATION

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Abstract – In today's world, globalization, technological and demographic changes make necessary and essential lifelong learning, while it is cooperative, global and universal. To achieve this challenge, is strongly required that schools and universities radically transform their educational systems and meet the demands to acquire the twenty-first century competencies. However, this can not be achieved without the necessary facilities (both, physical and virtual), the inclusion of the appropriate Pedagogy and technology, recognizing that people learn in different ways, motivating the students and accepting that learning is an inherent part of the daily life, therefore, permanent. This paper describes the importance of implementing Active Learning Spaces (formal and informal) in schools and Higher Education Institutions, which is justified through the collaborative Pedagogy, the needs and requirements of today's students, the involvement of educational technology and the use of Internet as a platform. Besides, it also presents the inclusion and adoption of these Active Learning Spaces by the schools of Mariano Galvez University (UMG), and its use by teachers and students.

Keywords: Active Learning Spaces (ALS), Collaborative Learning, Educational Technology, Pedagogy, Physical Space

Introduction

In the past two centuries, the world's population has grown considerably. As a result, global economies have experienced major changes. This, combined with other factors such as rapid technological development, the interdependence of modern societies and globalization make necessary for people to develop specific skills and expertise enabling them to enter in a social environment without training deficiencies. According to UNESCO countries whose populations acquire processing skills and knowledge construction applying them to work and daily life situations, may generate greater economic advantages over those countries that don't (UNESCO, 2003).

It is important to note that there are fundamental reasons to believe that to promote progress, development and modernization in societies, it is essential for people to have the abilities to build knowledge and the best form of use of this information. To achieve this, schools, universities and research institutions should be more involved in production processes, distribution and orientation of the use of this knowledge.

On the other hand, technological changes and the fact that modern societies should collaborate with each other, innovation and learning become essential (Chambers, 2010). According to this, it's necessary to change the traditional way of teaching, focusing in the learning process. However, classrooms are still relevant places where the teaching and learning process takes place. But learning occurs everywhere and at any time. Additionally,

in the modern world, students are immersed in technology, computers and mobile devices, digital means and wireless communications, enabling them to create knowledge and share it with others no matter where they are. Nevertheless, the current educational system still uses classrooms in the traditional way. This is a contradiction when compared with the needs of the educational system that today's students require.

Methodology

Due to these reasons, Mariano Galvez University has considered three important aspects for their new Formal Active Learning Spaces: Technology and Physical Space to support Pedagogy, which integrated make up the framework used in the design of these new environments as well as a platform inside the classrooms to allow the teachers to develop in their students the skills, abilities and competencies that is required in today's society in any discipline.

Several experts and organizations worldwide have suggested many initiatives and frameworks in Learning Spaces Design. However, UMG is using the Pedagogy-Space-Technology Active Learning Eco-system (Scott-Webber, 2011).

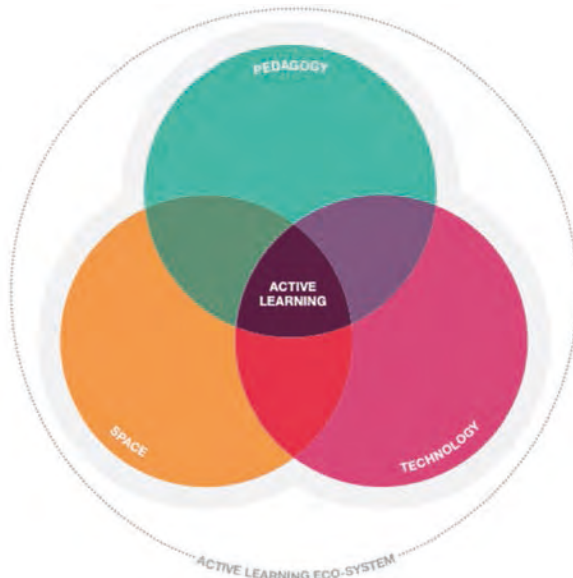


Figure 1: Active Learning Eco-System

It is important to note that Pedagogy always occupies the top position in this framework and should not change, since space and technology are the foundation on which Pedagogy is supported. In this model the Active Learning occurs in the intersection of the three areas.

The first important issue that UMG considered in the design of their Active Learning Spaces was the technology to support Pedagogy, as it plays a major role in the learning process of students of the modern world. The technological aspect has been so significant

that some researchers have claimed that the thinking patterns of modern students have changed. They think and process information in a different way from past students (Prensky, 2001). With this in mind, UMG has been installing technological tools to support modern pedagogical strategies in every formal learning space. These tools are:

- An ultra-short throw projector that converts any plain surface into an interactive whiteboard.
- A document camera (digital presenter) to present any document in a digital way with videoconferencing and recording classes capabilities.
- A personal computer.
- Interactive software that makes possible to record what is written on the blackboard and to upload these educational files to the Learning Management System (LMS) to have a register of each class.
- Internet Access for everyone.
- Sound.
- An Audio and Video (AV) plate that permits to connect other mobile digital devices to the projection system such as tablets, ipads, netbooks, etc.
- An automation plate managed over the network that integrates all these resources. Besides, with these automation plates it is possible to control the projectors and to administrate all these equipment.
- A Learning Management System to support face to face classes.

Another aspect UMG has considered was the replacement of the old and traditional school desks by new flexible, comfortable and ergonomic furniture that could be used in different ways. These attributes were appreciated using the “Node Chairs” that promote sharing information between peers in a very easy way and can be used in any pedagogical style. This flexibility is crucial since the change from a transmissive approach to the collaborative method, which cannot be completed from one day to the next, but can be done though time.

The University also needs security for the hardware installed in every environment. So, in every Active Learning Space there was placed a lectern or an IT table with adjustable LCD arms which hide away the PC monitor when not in use.

Besides the two preceding issues, UMG considered the 21st Century Pedagogy for today’s students. At the present time, learning is based on understanding and development of new skills necessary for critical thinking and solving complex problems. Additionally, Pedagogy has evolved from a transmissive to a collaborative model, framed by constructivist theory, which holds that each student constructs his own understanding of knowledge adding new information to his current knowledge. This theory also dictates that learning is best when it is contextual, active and social^[3], i.e., student’s understanding and engaging them in activities that use analysis and review through group discussions with partners and possible interventions with experts.

With this in mind, it is necessary to consider several pedagogical features in this modern educational world:

- Today’s students are social. They like to get in touch with peers and therefore have preference to do group activities.

- Students are inclined to discover, explore, experiment and analyze critically.
- Modern learners are inclined more to “do” than to “listen”.
- Learning must be student centered.
- Work must be interdisciplinary and project-based.
- Learning must be linked with reality.
- There are multiple intelligences and different learning styles.
- Learning should be comprehensive, permanent and meaningful.

All the technology and furnishing installed would be incomplete without the proper faculty training. With this in mind, UMG decided to design, develop and deliver continuously training for teachers. These courses were designed with three major pillars in mind (Brown, 2005):

- a) Active and social learning strategies
- b) An emphasis in human-centered design
- c) Technology that enrich learning

Taking this into account, each course has four units:

- Concepts of Active Learning Spaces and the use of the technology installed in every classroom
- Concepts of Pedagogy and Collaborative Learning
- How to use the learning management system as a support to face-to-face classes
- Web 2.0 tools.

To implement this project, Mariano Galvez University didn't hire external companies. Instead, the University used six teams from its Department of Innovation, Information and Technology. These teams are:

Technical Support: They are responsible for installing the pipelines, the data network and audio and video wiring. It is also a function of this team the installation, configuration and maintenance of the hardware.

Electrical Installation: For security reasons it was decided to make a new electrical wiring, thus this team has the responsibility to install the electrical pipelines and its respective wiring. They also made the electrical panels with the proper groundings.

Telecommunication: These are the people responsible for network configuration.

Infrastructure: For security and cosmetic reasons, it is required that the pipes and wiring should not be visible, so there is a team responsible for the installation of dry walls and finishing touches.

Development: Their function is to create web interfaces to use the Learning Management System and to keep the system working.

Center for Innovation in Learning: This unit is responsible to design and develop faculty-training courses.

In this way, Mariano Galvez University has transformed over 450 traditional classrooms into real Formal Active Learning Spaces to enhance student's learning, to facilitate a real

commitment among students and teachers, students and peers, collaborative work in pairs and small groups, development of team projects, presentations by students to their peers, content creation and evaluation through problem-based curriculum. These new environments are used not only by the University but also by the schools that are part of UMG.

Results and Discussion

To evaluate these facilities about their use, two Web-based surveys were designed, one for teachers from high school and one for high school and University students. These questions are about their satisfaction and use of the new educational environments. Replies were received from 729 students and 37 teachers from high school. When asked the students about their satisfaction with the inclusion of these new environments, 84% of the students rated the new spaces between the ranges of “good” to “excellent”. Additionally, 98% agreed they would not like to recover the traditional classrooms.

85% of the students from high school surveyed indicated that the inclusion of these Formal Active Learning Spaces has substantially improved their learning, and 55% stated they have changed the way they receive their classes considerably. This parameter reveals that teachers are changing the way they teach. In other words, they are migrating from transmissive pedagogical method to the collaborative.

The results showed that the majority of students from high school are very satisfied with these new environments and they have taken advantage of them in a good way. They also feel them comfortable and attractive.

When teachers took this survey the results were: 92% qualified the new Active Learning Spaces from ranges of “good” to “excellent” and 100% would not like to recover the traditional classrooms. 88% said that these new spaces have improved student’s learning and have changed the way they teach.

Another web-based survey was given to approximately 22,000 students from Mariano Galvez University (main campus only). Replies were received from 4,143 students with the following results: 67% rated the new educational environments from ranges of “good” to “excellent”. 23% qualified the environments as “regular” but they indicated that the reason was of the old desks still placed in the classes because only the technology tools had been installed but not the new “node chairs”, yet. 69% stated that they had improved their level of learning with the use of these new Active Learning Spaces.

Conclusions

Both surveys showed very similar results in all the questions and indicate that the majority of students and teachers are highly satisfied with the new environments. Additionally, both evaluations indicate that the new Active Learning Spaces have improved student learning and increased their sense of belonging to their institutions. However, the evaluations also showed that it is necessary to train teachers continuously not only in the use of technological tools, but also in Pedagogy and in didactic aspects.

This study was conducted with the inclusion of Formal Active Learning Spaces. Nevertheless, it is recommended a similar research for Informal Learning Spaces, which are located in libraries, corridors, cafeterias and places where students get together to work collaboratively.

For future perspectives for research it is highly recommended to make studies on the impact of the inclusion of these new environments within specific disciplines.

Acknowledgements

First of all, UMG recognizes that God has helped us and has given us everything to implement this project. As a Christian University we believe that all that we accomplish is because of the Grace of God. We share our faith, by placing a biblical verse in all of our new Active Learning Spaces. Subsequently, the installation of the new Active Learning Spaces has involved a range of stakeholders and a number of people and departments of the University who have worked as a team to reach the goal. Finally, the authors would like to thank the teachers and the students who participated in the research as a group of participants who took the time to reply the web-based surveys.

References

- Dede C. (2005). *Educating the Net Generation, Chapter 15*. Educause. Boulder, Co, USA.
- Prensky M. (2001). *Digital Natives, Digital Immigrants*. MCB University Press Vol. 9 No. 5. USA.
- Emery R. (2012). *Priorities in the Classroom: Pedagogies for High Performance Learning Spaces in Informed Design of Educational Technologies in Higher Education: Enhanced Learning and Teaching*. Berkeley, California. USA.
- Poole P. & Wheal A. (2011). *Learning, Spaces and Technology Exploring the Concept*. Canterbury Christ Church University and JISC. UK.
- Radcliffe D., Wilson H., Powell D. & Tibbetts B. (2009). *Learning Spaces in Higher Education: Positive Outcomes by Design*. The University of Queensland and Australian Learning & Teaching Council. Australia.
- Bransford J. (2000). *How People Learn Brain, Mind, Experience, and School*. National Academy Press. USA.
- Corcorran S., Scott-Webber L. (2011). *Active Learning Spaces Insights, Applications & Solutions*. Pencils Down. USA.
- Moore M., Tait A., Zaparovanny Y. (2003). *Aprendizaje Abierto y a Distancia – Consideraciones Sobre Tendencias, Políticas y Estrategias –*. UNESCO. Uruguay.
- Chambers J. (2010). *The Learning Society*. Cisco Systems, Inc. USA.
- Chambers J. (2008). *Executive Action Plan*. Cisco's Global Education Group. USA.

LOCATION BASED GAMES AND INTERGENERATIONAL LEARNING FOR NATURE CONSERVATION VOLUNTEERS: INVOLLEN PROJECT

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Abstract – Intergenerational Learning (IL) describes the way that people of all ages can learn together and from each other. Beyond the transfer of knowledge, IL fosters reciprocal learning relationships between different generations and helps to develop social capital and social cohesion in our ageing societies. On the other hand, the role of Information and Communication Technologies is becoming even more important for all generations. In Invollen project (Intergenerational Learning for Nature Conservation Volunteers, LLP, Gruntvig) the learning methodology and the new tools are associated and contribute to the volunteering in nature protection which includes any non-remunerated and freely chosen activity exercised in general within in a non-profit organisations: association, NGO, trade union or public structure. The Invollen model *i.* offers opportunities to senior citizens to become involved in voluntary activity for nature protection and preservation, thus improving their quality of life, self-esteem and self confidence, while improving their knowledge on a number of fields, including volunteering and IT, *ii.* encourages youngsters of secondary schools to become volunteers for nature protection, *iii.* improves the capacity of NGOs, schools and adult education institutions to deliver innovative adult education while enabling their staff, especially those involved in environmental education, to improve their qualifications and career prospects.

This is reached through the collaboration within focus groups in which elders and students work together in a participative process, in which learning is guided by the figure of the ‘learning facilitator’. The use of IT tools allows the learners to create their own learning material and share it with others, but also to attract younger generations.

Eventually, Invollen enhances the preservation of protected areas through voluntary activity and exploitation of the knowledge and traditions of past generations, but also enhances the awareness of local people on the environmental value of their surroundings.

Keywords: Intergenerational learning, Invollen, mobiles, nature conservation, secondary schools, serious games.

Introduction

In recent years volunteering has been increasing, encouraged by the UN policy. 2011 year was declared the 2nd European year of Volunteering and the EU shows strong interest in it especially for its contribution to social cohesion, building European identity and values. Volunteering means also active citizenship, although generally nature conservation volunteering is exclusive for those 25-45 years old. Indeed, senior citizens are often considered vulnerable and physically lowly alert whereas youth have generally a low interest

in nature-related volunteering. The project initiative follows the European Year for Active Ageing and Solidarity between Generations 2012, aiming to contribute to raising awareness for active ageing and posing «the challenge to politicians and stakeholders to improve opportunities for active ageing in general and for living independently, acting in areas as diverse as .adult learning, volunteering, IT services» (Bird, 2007).

However, volunteering for nature protection/conservation offers valuable resources that produce added value for local communities, the society at large and the environment.

Involen project challenges to bring together two age groups (youth and elders) living close to a protected area through an intergenerational learning process while encouraging volunteering for nature conservation. Intergenerational Learning (IL) describes the way that people of all ages can learn together and from each other. Beyond the transfer of knowledge, IL fosters reciprocal learning relationships between different generations and helps to develop social capital and social cohesion in our ageing societies [...] (www.enilnet.eu). Nature protection can be an ideal ground for IL in which seniors with countryside experience can bring valuable knowledge of nature conservation models and methods, based on skills and traditions that are in risk of being forgotten.

Most of knowledge of the local territory is stored in the elders' memory and tradition, on the other hand, nature protection is often explained by ONG and scientific organisations who deal with it. Therefore, the knowledge transfer between different actors might be done using a simple language, understandable and meaningful, in order to make easier the understanding of nature issues which consequently need protection actions.

An additional tool useful to interconnect generations is represented by Information and Communication Technologies. Nowadays it is evident how much youth are keen to use ICT for sharing moments, emotions etc. and mobile technology is also the most affordable and multitasking for such use. ICT can be of aid in Intergenerational Learning: pupils skills on ICT and elders' knowledge combine and knowledge transfer takes place.

To summaries, Involen aims to:

- create an innovative and interactive learning methodology for applying the practice of intergenerational learning in the conservation of protected areas that is easily transferable to other protected areas and communities throughout Europe
- create a Learning Guide addressing “learning facilitators” providing step-by-step advice in implementing the learning methodology; and a learning tool kit, addressing both facilitators and learners, offering examples of materials and activities that can be included in the learning process.
- pilot the learning methodology and apply it more widely through schools, NGOs and adult education institutions
- disseminate widely the project activities and results, through the internet, the social media, national workshops and an international conference
- spread the practice of intergenerational learning in the adult education system.

Methodology

Involen project addresses to the participation of young and senior citizens in voluntary action for nature conservation through continuing learning. The youth dynamism and

energy can interact with seniors' knowledge and skills through an Intergenerational Learning guided process. Participants are encouraged to become actively involved in voluntary activities which help to develop self-esteem, self-fulfillment and a higher status within their communities. Involon applies a model for Intergenerational Learning on Nature Conservation Volunteers.

Initially, a focus group is created, gathering three elders, seven pupils and two facilitators: the small group facilitates the learning process. Facilitators (teachers from the school or ONG personnel) help the learning process and plan the activities.

Six work units are organised for knowledge transfer in nature conservation issues: the methodology will be piloted, evaluated and then implemented throughout Natura 2000 Protected Areas.

1. Individuation of competence needs, knowledge on intergenerational learning, protected area issues and ICT through a questionnaire.
2. Demonstration of the ICT game, discussion of the potentialities and the possibilities in game development
3. Collection of stories, legends, tells by elders who live in or close to the protected area (Fig. 1). The videos or other material will be translated into English and available for public access.
4. Selection of one story to develop as serious game in ARIS location based games platform.
5. Visit to the area for volunteering activities (i.e. to clean up the path trails, collection of materials like pictures, things, videos on site etc.)
6. Development of the serious game using ARIS location based games platform (Fig. 2).



Figure 1. Meeting between youth, the elder and the facilitator (the teacher).

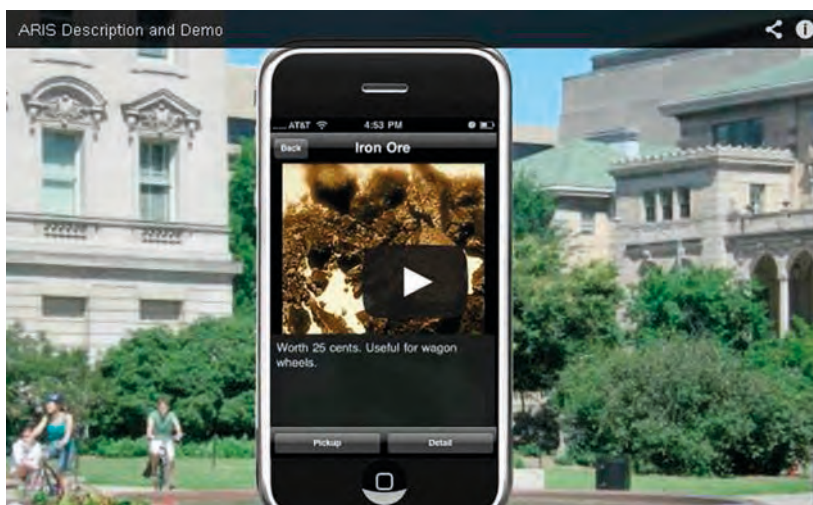


Figure 2. ARISGAMES location based game open source platform for iPhone (www.arisgames.com).

The training on Intergenerational Learning for Nature Conservation Volunteers of the target groups takes place through alternative, innovative methods, based on exchange of experience between generations, hands-on learning and ICT support through a website which has also a database of visual and narrative material; and the learning games to be constructed by trainees.

This method is expected to have benefits to learners: learning on nature conservation, creating new friendships; create close intergenerational links and continue offering their services voluntarily for the benefit of the environment and the community.

The project will also provide the target groups with the opportunity to use and disseminate the knowledge and skills acquired, integrating them not only in their learning process, but also in their everyday life, thus supporting them in becoming life-long learners.

Results and discussion

In Italy, Involen pilot test has been developing in Monti Livornesi Provincial Park (close to Livorno city). It gathers the students from the secondary school Teseo Tesei (Istituto Comprensivo Micali), elders (grandfathers and volunteers of local associations) and teachers and one WWF activist as facilitators. The project is at the beginning and only the training course on Intergenerational Learning has been attended by the facilitators.

Some of the project outcomes will be tangibles, while other will concern the sphere of relationships among diverse persons who have different experiences and knowledge but the willing to work together.

Real outcomes will be:

- Workshops and webinars on Intergenerational Learning and ARISgames platform.
- Learning Toolkit with information and tips on the learning methodology and ICT guidance on ARISgames

- The stories and narratives from elders collected through interviews or other media. They will be stored in an online database, available in English and in the country language (Fig. 3).
- Helpdesk for remote assistance during the serious game development
- a collection of serious games that will participate to an international competition which will award the best games in the final International Conference

Conclusions

The Involen project model has been testing at the moment. Some conclusions can be draft only on the first phase of the project which concerns the creation and the interaction within the focus group.

In the Italian context, the associations of volunteering generally register lack of volunteers while those more active are mainly elders, retired, who have time to devote. On the other hand, rarely the schools have activities which make connection between volunteering associations and pupils but also between elders and pupils and this relationship remains stronger within the family frame. The cover of this gap is the challenge for Involen partnership, especially in those territorial contexts where there is more scepticism toward the relationships among people, as for instance in the urban context. Three different age groups that are not necessarily linked by family ties will work together for their common interest in nature protection of their close protected area. Their competence needs will be identified in order to cover the gaps of knowledge useful to reach the project objectives and they will surely learn from each other.



Figure 3. The student interviews elders.

The project starting has been successful even if difficulties has been already met. If the students have demonstrated to be keen and very enthusiastic of the project aims, teachers have already identified some problematics such as the bureaucracy for the organisation of the field trips and the organisation of groups for the development of the game scenario. Moreover, if on one hand working with a small number of students is ideal in Intergenerational learning (ratio 1:2 between elders and pupils), on the other hand, the school context should not be exclusive. Therefore, some compromises should be taken ongoing. About elders, we also hope in their long term involvement. Eventually, we hope that Involen model would be useful for local organisations who work in nature protection and conservation, which can develop such kind of cooperation for the interest of the community.

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References

Bird W. (2007). *Natural Thinking: Investigating the links between the Natural Environment, Biodiversity and Mental Health*, 1st edition. Royal Society for the Protection of Birds, UK.

Web references

Declaration of the European Year for Active Ageing and Solidarity between Generations, visited on June 20th, 2013. <http://europa.eu/ey2012/ey2012main.jsp?catId=971&langId=en>

www.enilnet.eu, visited on June 20th, 2013.

www.involen.eu

THE ROLE OF TEXTBOOKS IN SCIENCE EDUCATION: A CASE STUDY ON HUMAN MIGRATIONS

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Abstract – An important aspect of science education is represented by textbooks. Textbooks provide a context for understanding the relationship between knowledge and values, and to observe how the research results are presented to the society. In this paper we analyze how the phenomenon of human migrations is dealt in Italian school textbooks. Basing on the official directions of the Italian Ministry of Education for school curricula, we concentrated in particular on books of geography and history of specific classes. We produced a grid of analysis which includes several dimensions, with the aims of detecting the differences between the current scientific debate on human migrations and the information contained in the textbooks, and of revealing the value system conveyed implicitly and explicitly by the images and the text. While scientific research shows that human migration in Italy is an extremely heterogeneous phenomenon, on the textbooks we found an oversimplified representation of it. Implicit values such as biological determinism and sexism emerge, and critical gender issues are present.

Keywords: determinism, human migration, sexism, social sciences, textbooks

Introduction

Alongside the teaching and learning methodologies in the classroom and laboratories, a crucial tool for enhancing science education is represented by textbooks. Not only textbooks provide an important context for understanding the relationship between knowledge and values, but they are very useful for observing how the research results are presented to the society. Textbooks convey, explicitly and implicitly, ideological and epistemological values and they include a multitude of open or hidden messages in the text as well as in the images (Caravita *et al.*, 2007, 2008; Clément and Hovart, 2000; Caravita and Valente, 2013; Jacob 1988).

The theme we choose for this case study is human migration, that is covered by life sciences as well as by social sciences. Migration in Italy is an extremely heterogeneous phenomenon. As the demographic and socio-economic research pointed out, this diversity can be related to many different aspects, such as countries of origin, expectations, length of stay, education and skill level of the immigrants as well as causes and preconditions of immigration, contexts of labour market, policies on immigration which in different periods encouraged or discouraged different types of legal migration (Livi Bacci, 1978, 2010; Castels and Miller, 1993; Bade 2001).

Our study is primarily concerned with assessing the extent to which this complexity is presented in textbooks, or if, on the contrary, they operate a simplification of the phenomenon. The social debate on migration is full of stereotypes, but to what extent textbooks manage to overcome them? What implicit and explicit values textbooks express

on immigration? How values like biological determinism and sexism are present in the representation of migration in the textbooks? Do textbooks offer the tools to understand and act as citizens on the migration policies?

Methodology

In Italy, migration is not present as a curricular topic in any school subject, but it is mentioned in a fragmented way in many subjects. This fragmentation exists somehow also in the research on the topic, which is present in many different disciplines often with little communication among the different fields (Morawska, 1990; Bonifazi, 2007).

Starting from the official directions of the Italian Ministry of Education for school curricula (“Indicazioni Nazionali”), we identified classes and subjects in which the theme of migration is explicitly named, which resulted to be geography in the first year and history in the last year of higher secondary schools. We also decided to consider history and geography of lower secondary schools, although the new ministerial directions do not describe the details of the curricula but merely give general guidelines.

The methodology followed for textbooks analysis is based on the theoretical framework and on the results of the Biohead-Citizen European project (Caravita and Valente, 2013, Caravita et al., 2008; Quessada et al., 2008), in which the analysis dealt with some subjects of Biology, Health and Environmental Education mainly in science textbooks.

We produced a grid of analysis that included several dimensions, such as educational style, occurrences of words, explicit and implicit values (for text), gender of individuals and groups represented, context, implicit and explicit values (for images). The grid have been designed with two main objectives: first, to detect the differences between the current debate on immigration and the information contained in the textbooks; second, to reveal the system of values conveyed implicitly and explicitly by the images and texts.

Results and discussion

Human migration is not at all prominent in geography and history textbooks, and the number of pages dealing with the topic is very limited, as one can see in Table 1.

The fragmentation of the scientific research on the topic has probably influenced the way in which the themes have been transposed in the educational context, causing a large *Delay in the Didactic Transposition* (DTD) (Verret, 1975; Clement and Hovart, 2000, Quessada and Clement, 2007). In fact, despite we can hardly expect an exhaustive treatment of

Table 1. Number of pages dealing the topic of migration

TYPE OF BOOK	% OF PAGES ON MIGRATION	NO. OF PAGES ON MIGRATION / TOTAL NO. OF PAGES
Geography lower secondary school	4,6 %	152/3294
Geography higher secondary school	2,4 %	43/1808
History lower secondary school	1,2 %	26/2269
History higher secondary school	1,6 %	25/1560

the topic for the reasons we explained above, some important aspects seem to be utterly ignored in textbooks.

This is for instance the case of the legislative references, although the laws and decrees deeply influenced migration flows and have partly determined the contours of the phenomenon, encouraging or discouraging particular type of migration projects, defining and redefining the boundaries between legality and illegality. The reconstruction of the legislative process could also enlighten the cultural change around the issue of immigration and the political exploitation of the phenomenon.

In our analysis, we also found the almost total absence of other important results highlighted by the socio-economic and demographic research, such as the difficulty of producing a classification of migration steps suitable for all contexts, the complex relationship between preconditions and causes of migration, the relation with supply and demand for labour, the “cascade effect” of prejudice. In particular, the relation of causality in presenting the causes of migration is often deterministic; interestingly enough, social and biological determinism have been found also in the analysis of science textbooks of Biohead project.

While it is clear that it is not trivial to see all these aspects in the textbooks of history and geography, the drastic reduction of complexity and the frequent choice of not problematizing the phenomenon does not help students understand the issue, and to grasp the different forms it takes over time and the multiplicity of causes, interests and life experiences. The simplification may make too easy to settle for a “we” and a “they”, a dichotomous approach that is sometimes used to drive the positive feelings of solidarity and humanity, but does not allow go beyond compassion, tolerance towards newcomers, and sense of duty.

The limited understanding and knowledge can form the substrate for an “aversive racism”, in particular when emotional aspects are present, conveyed by the text and especially by the pictures. As an example we can take the frequent presence of images with boats full of “illegal” migrants, particularly iconic, which immediately suggest the threat of an “unsustainable” situation. A few books make references to thousands of people died in the waters of the Mediterranean, and even rarer are the books which include images on a different register.

Because of the choice of the subjects (history and geography) we do not expect to find an exposition of the problem from the point of view of biology. Only in a geography textbook we found a hint on the positive role of life sciences in order to discard the concept of human race.

In our analysis we also considered gender issues. Immigrant women are much less than men represented in school textbooks, and almost never in a work environment, whereas they are often depicted with their children and as victims. Despite working migrant women play a crucial role in the labour market (Castels and Miller, 1993; Koser and Lutz, 1998), and especially in the Italian context, in textbooks women are relegated to a more “traditional” role.

Of course, in addition to the limits listed above, we also mention the merits. In few books the subject is treated beyond stereotypes, also representing figures of immigrant women as entrepreneurs. However, even in textbooks that develop a constructive approach to immigration, we observe a general tendency to “reassure”, especially on issues of security and identity, an attitude that often suggests the presence of a threat.

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References

- Bade K.J. (2001). *L'Europa in movimento. Le migrazioni dal Settecento ad oggi*. Laterza.
- Bonifazi C. 2007. L'immigrazione straniera in Italia. Il Mulino.
- Caravita S., Margnelli N., Valente A. & Luzi D. (2007). Intreccio tra conoscenza e valori in Educazione Ambientale: una griglia per analizzare libri di testo. In Pitrelli N., Sturloni G. (Eds). *Atti del V Convegno nazionale sulla comunicazione della scienza*. Polimetrica.
- Caravita S., Valente A., Luzi D., Pace P., Khalil I., Valanides N., Nisiforou O., Berthou G., Kozan-Naumescu A. & Clément P. (2008). Construction and Validation of Textbook Analysis Grids for Ecology and Environmental Education. *Science Education International Journal*, 19(2), 97-116.
- Caravita S., Valente A. (2013). Educational approach to Environmental complexity in Life Sciences school manuals. An analysis across countries. In Khine M.S. (Ed.). *Critical Analysis of Science Textbooks, Evaluating instructional effectiveness*. Springer.
- Castels S. & Miller M.J. (1993). *The Age of Migration: International Population Movements in the modern world*. Guilford Press, New York.
- Clément P. & Hovart S. (2000). Environmental Education: analysis of the didactic transposition and of the conceptions of teachers, In Bayerhuber H. & Mayer J. (Eds). *State of the art of empirical research on environmental education*. (pp.77-90). Waxmann Verlag, Münster.
- Jacob C. (1988). The textbook and the social construction of reality. *Technologies, Idéologies Et Pratiques*, 81 (1-4), 333-341.
- Koser K. & Lutz H. (1998). *The new migration in Europe. Social Construction and Social Realities*. Macmillan.
- Livi Bacci M. (1978). *La trasformazione demografica delle società europee*. Loescher
- Livi Bacci M. (2010). *In cammino. Breve storia delle migrazioni*. Il Mulino
- Morawska E. (1990). The sociology and historiography of migration. In Yans-Mc Laughlin V. (Ed.). *Immigration Reconsidered. History, Sociology and Politics*. Oxford University Press.
- Quessada M.P., Clément P., Oerke B. & Valente A. 2008. Human Evolution in Science textbooks from twelve different countries. *Science Education International*, 19(2), 147-162.
- Quessada M.P. & Clément P. (2007). An epistemological approach to French curricula on human origin during the 19th & 20th centuries. *Science and Education*, 16(9-10), 991-1006.
- Verret M. (1975). *Le temps des études*. Librairie Honoré Champion.

GENERIC COMPETENCES AND SCIENCE AND MATHEMATICAL EDUCATION: PREPARING A NEW LEARNING ENVIRONMENT

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Abstract – Mexican Higher Education (MHE) institutions face a major problem regarding the preparation students have when they receive them from the Mexican Upper Secondary Education System (MUSE). Students graduating from MUSE have low and mediocre performance in reading, writing, Mathematics and Science as different kinds of indicators show, including PISA 2009. Despite recent reforms in MUSE its teaching and learning at the school level remain traditionally geared towards memorizing abstract knowledge, definitions, procedures and algorithms. This paper deals with the recent experience and partial results of an institutional program of education research and development support, for higher education faculty interested in incorporating a generic competence approach to their courses.

Keywords: Higher education innovation, institutional research and development, higher education teaching and learning, generic competences, teaching and learning support

Introduction

In this paper it is argued that Science and Mathematics teaching in Higher Education (HE) can be substantially enhanced by means of educational research and development support. The evidence for this assertion stems from a project at Universidad Autónoma Metropolitana (UAM) in Mexico. UAM is one of the most prestigious academic institutions in the country and the project has been taking initial steps for gradually changing the learning environment of first degree courses, at the classroom level in the institution. This goal is meant to facilitate higher quality and higher graduation rates in the University. In this case, the support consists of collaboration, on the part of a team of experts in pedagogical content knowledge in verbal communication and mathematics, with faculty interested in including one or several of three generic competences deemed of strategic importance for UAM. The three competences are: i) written and oral literacy and professional communication, ii) the application of formal languages to professional work and iii) the use of content knowledge for problem-solving.

The relevance of this initiative can be understood in view of problems facing Mexican HE and its rapid growth in the last sixty years. Up until the 1950's, the average number of years of education of Mexican adults was barely two years, which meant that educational policy sought as an absolute priority to extend primary schooling to all 6 to 12 year old children. Secondary education and higher education were limited and elitist. In 1950 Mexican Upper Secondary Education (USE) enrollment was still a modest 37 thousand and there were only 40 thousand students in HE in a country with a population of 25 million inhabitants (OCDE, 1997).

Presently, the country has over 116 million inhabitants, education coverage has increased

dramatically and USE has been included as part of compulsory education in 2012 (Sexto Informe, 2012). USE has over four and a half million pupils and HE for its part has increased in size to nearly three and a half million students today (Sexto Informe, 2012). These results were achieved thanks to the exertion of an extraordinary pressure on both USE and HE levels of education in order to keep creating new institutions and enlarging existing ones. Hiring teachers for USE and HE, mostly on an hourly basis, has had, under such circumstances, prevalence over training them. The same impetus has led to lowering and flexing minimum requisites for teaching which at its turn induced lower entrance requirements to USE and to HE (INEE, 2012b). Full time faculty in HE rarely reach 50% of all academic staff. Additionally, it must be taken into account that Mexican society is highly heterogeneous, in cultural and economic terms and there remain huge social and regional inequalities. Education is, not surprisingly, also heterogeneous in quality and in social and regional coverage. Education has in, consequence, large equity issues. The growth process of both USE and HE has been largely determined by these conditions affecting, to the present, the way institutions have been organized. Teaching and learning practices and results are heterogeneous. When in the 1990's in addition to the tenet of educational coverage new attention was given to the improvement of the average academic and professional quality of HE and USE, existing inertia proved to be predictably resistant and resilient. New orientations also had a part in emerging difficulties for reforms to take hold, as they often lacked clarity and usefulness, contributing to confusion among staff and students. Teaching and learning both in USE and HE continue to emphasize retaining abstract knowledge - definitions, procedures and algorithms - over understanding and competency (Narro et al., 2012).

As a result, a large proportion, and in some cases, nearly the majority of students entering higher education institutions in Mexico has problems dealing with literacy, basic mathematics and with the expected science competency necessary in HE courses (INEE, 2012a, 2012b; OECD, 2009). Teaching in HE is burdened with a permanent conflict between maintaining high standards and having a large proportion of students failing their courses or lowering standards. Disappointment and frustration are current and common in staff teaching experience. Teaching first degree courses, at the most prestigious universities, is additionally burdened with the lack of recognition research has, in terms of bonuses, which are an important dimension of faculty income, as it can double or triple basic salary. Institutionally, such factors exert influence on academic processes and convey an impact on general results (Narro et al., 2012).

This paper deals with a project geared towards taking one set of modest but effective initial steps for gradually changing the learning environment of first degree courses, at the classroom level, and facilitate higher quality and higher graduation rates in Universidad Autónoma Metropolitana (UAM). UAM is one of the most prestigious academic institutions in the country. It was created in the mid seventies in Mexico City. The size of the university has been comparatively stable for the past 25 years, its present student population is of over 41 thousand distributed in 5 campi (6). New entrants to UAM are around 12 thousand students, while graduates number 4.4 thousand yearly. First degree programs are designed to last between four and a half to five years and only 38% achieve then regularly. Up to 54% of those who enter programs graduate after nine years. Such efficiency severely weighs on resources and costs, limiting the possibility of increasing the number of students being attended in a given period. After 38 years it still faces a major challenge in terms of assuring, as it was mandated to do in its founding charter that all graduates of its first degree programs possess three main competences: written and oral literacy and professional

communication, application of formal languages to professional work and use of content knowledge for problem-solving. Nowadays these competences are seen not only as goals but also as necessary foundational elements for learning and for professional life (UAM, 2012).

Methodology

The university organized an educational research and development project to promote the three main competences, phase I, consisting in a survey reviewing all academic activities undertaken throughout the institution in order to promote these three generic competencies. The survey was carried out in its 5 campi and its 15 academic divisions - there being three divisions in each campus out of the following five divisions: social sciences and humanities, basic sciences and engineering, architecture and design, science and engineering and health and biological sciences.

The general survey comprised a questionnaire for all and each of the 15 divisions (three divisions of the following four in each campus: the Social Sciences and Humanities Division, the Design, Arts and Sciences Division, the Physics, Mathematics, Chemistry and Engineering Division and the Biology and Health Sciences Division) and 11 personal interviews in depth with the five rectors (campus presidents) and six deans and highly respected professors. Even though I do not belong to this university, it was considered that it would be preferable to have external peers undertake the review exercise, so as to take distance from existing internal debates concerning the institution's future. The general survey focused on: identifying the type of curriculum or non curriculum activity undertaken, its scope in terms of targeted population, goals to be achieved, incidence of such goals on academic ends and means, results obtained, type of impact evaluation on competence development and lessons obtained. A total of almost 250 activities were reported to have taken place in the last year.

The survey was undertaken between April and June 2012. Results of the survey showed that nearly 95% of all these activities were related to the generic competencies in a vague and indirect way, as most of them were content centered activities consisting of teaching and dissemination of information, procedures, algorithms, formulae, rather than being focused on developing abilities and competences. No impact evaluation was undertaken on the effect of the activities on competence development as there appeared to be a general lack of procedures, guidelines, materials and information regarding what is a competence and what is its specific relationship to a given first degree program. A major institutional omission appeared in the survey regarding the definitions of all three competences. Activities and courses regarding them are unsurprisingly varied and diverse in a non rational way, as are criteria for designing, organizing, evaluating and integrating them into the curriculum. The connection with other academic activities such as teaching and planning remains undetermined.

In the interviews it was expressed that curriculum reform in the University has not dealt with this paucity of criteria as educational and pedagogical knowledge is not clearly identified as being sufficiently robust to provide the necessary answers. Generic competencies are not yet clearly identified as being distinct from content knowledge. Therefore there is no clarity as to the need for organizing their teaching and learning at the university on a different basis, other than changing content knowledge. The survey also showed that faculty expected students to have the three competences when they entered HE. Staff also expected students to further develop them to a professional level while studying at the

university, even if they did not explain how this is supposed to happen. As a conclusion, there appeared a great gap between expectations on students' performance in terms of generic competences and the institutional supply of activities to promote the three competences. The survey recommended undertaking three parallel activities. One was setting up a commission to propose an indicative definition of the three generic competences: literacy and professional communication, basic and domain specific mathematics and problem solving using content knowledge. The commission submitted its proposal in May 2013. The second recommendation was reviewing the design of the entrance examination, in order to align it with the definitions offered by the commission.

The third activity recommended was setting up, as a first step, an education research and development program to promote and disseminate an education and teaching culture open to the consideration of didactics, pedagogical content knowledge, innovative academic assessment, collegiate work, the development of the three generic competences on the part of students and the use of information on the academic performance of university students as a tool for academic planning. This program is meant to support teachers interested in working with this orientation.

As part of this recommendation, a phase II of the Project of Educational Research and Development was authorized and a convocation was issued in January 2013, signed by the heads of the 15 divisions of the University and it was opened to all academic members of the university that were going to undertake teaching during the Spring Term and who were interested in participating in a project geared towards designing a new teaching proposal for their own individual courses. Registration was done in line. Applications were submitted during the first two weeks of March 2013. All 47 applicants were admitted, but only 42 managed to write up a schematized proposal of intervention and have remained and worked as programmed in the project. Surprisingly, in terms of discipline, out of 42 participants, only 8 belonged either to the Social Sciences and Humanities Division or to the Design, Arts and Sciences Division, all the rest are full time faculty in the Physics, Mathematics, Chemistry and Engineering Division or the Biology and Health Sciences Division.

Applicants were required to submit a letter of intent identifying, according to their own experience, problems in teaching and learning: i) regarding understanding, integrating and applying domain specific concepts; ii) relative to writing the type of essays and projects demanded by the course iii) applying and integrating previous knowledge to academic work.

Participants were offered a six hour workshop in two sessions, in three different campi, during the first two weeks of April in order to give participants a general overview of the three generic competences in different sources: UAM's own Institutional Development Plan 2011-2024; Mexico's results in OECD's PISA 2009; the Report submitted to UAM authorities in May 2013 by the ad hoc commission set up, as well as research based results on the situation of generic competences in USE and HE in Mexico and in the University (Zorrilla, 2010).

Letters of intent were reviewed and a few recommendations were suggested in the course of the workshop. These recommendations referred to identifying a coherent and viable strategy for working the objectives being sought. It was also stressed that it was crucially important to be as clear as possible in all communication with students, especially in all matters connected with evaluation, the objectives of the course and the fact that a new approach was being introduced regarding generic competences. It was also suggested that an initial diagnosis/assessment of students' mastery of content knowledge and academic abilities pertaining to the course was in place. The format and templates for the report that participants were to deliver towards the end of this phase of the project were given,

with a view to have it published in a e-book. Participants were asked to transform the intentions set out in the letter into a schematized proposal for working with their students the course being offered in the Spring term commencing at beginning of May 2013. The second session of the workshop was entirely given to presentations from the participants and a general discussion.

During the last week of May 2013, a series of visits were organized so as to review progress in the intervention and the way the proposal was adjusted or changed. Most participants expressed that their objectives proved to be too ambitious and more time had to be given to working with their students' effective level of performance. While almost all teachers showed certainty about maintaining the general objectives of the proposal, they were somewhat surprised to find that their teaching was not all they thought it was. The most general recommendation given to all participants was not to forget to write down in their field diary or equivalent all the vicissitudes of their intervention. It was also underlined that in the literature on education there was virtually no qualitative data on what happens in HE classrooms from the perspective of teaching a given course, or from the perspective of educational innovation, for which their activities certainly qualify. These features, they were told, made additionally valuable their experiences.

At the end of June 2013, participants were asked to render the partial results of the intervention in a poster. A poster session was organized to that effect. 35 participants produced a poster and all participants had the chance to meet all their other colleagues in the Project.

In the middle of July, as the Spring term came to an end, a questionnaire was prepared for them to answer on line, four days before the holidays. The partial results of that questionnaire are presented below.

Results

It is relevant to contrast the views expressed by participants initially in their letters of intent with the partial results reported in the on line questionnaire. On the letters of intent students were credited with having difficulties or inabilities *vis a vis*: i) working with mathematical expressions and the interpretation and application of results obtained in mathematical operations; ii) the description of graphs, the determination of tendencies and the interpretation of the occurrence of minima, maxima and derivatives; iii) the integration and application of content knowledge, the use of the algorithms they know for other purposes; iv) working with domain specific texts and writing reports identifying and communicating central concepts; v) the acquisition of the proper technical vocabulary; vi) the discussion of their argument persuasively in any given text; vii) the development of the high level of concentration on intellectual and academic work that is required of them; viii) to infer conclusions and plausible hypothesis either from the literature or from research; ix) to elaborate original ideas and to discuss them convincingly.

Of the total 25 problems mentioned in the letters of intent, 23 referred to problems students have and only two alluded to other factors, one referred to the general infrastructure of the university facilities and the other one to teacher's inability to understand the problems he faced. Obviously, it was clear that the general opinion overwhelmingly emphasized student problems.

As the project unfolded, these tenets began to change. In the visits paid to participants, once the Spring term had begun, in the five campi, most teachers – many of whom have the highest academic standing and have a long academic experience stretching over twenty

or more years – were very surprised to admit that under the new perspective offered by participation in the project their own routines and methods showed inconsistencies and inefficiencies that were not perceived. But at the same time, some of them also discovered new possibilities and explored new activities. Some of them were glad they had entered the project but were somewhat out of their usual balance. This feeling seemed to be nonetheless constructive as they also mentioned that it led to a new search. These results had not been considered or contemplated beforehand at the beginning of the project. Some others, nonetheless, were surprised to find that the expected results were not forthcoming and they seem to confirm them their original tenets. In other words, most teachers reported a new awareness of their own teaching and the learning process of students. While at the same time, a few others confirmed their previous expectations. The results of the on line questionnaire throw some light on these differences.

The questionnaire

Out of 42 participants, 28 have already completed the online questionnaire, the other 14 have opened it but have not completed it.

The first question had four sections. The first section enquired what percentage of their students in the intervention group had an academic preparation, both in terms of content knowledge and competences, well below the required level for the course. The second one asked what percentage had an incomplete preparation below the required level. The third question referred to what percentage had a sufficient preparation for the course and the fourth what percentage had a robust preparation.

Participants consider, in aggregate terms, that 21.2% of their students were well below the required level, 26.2% had incomplete preparation below the required level, 37.9% had a sufficient preparation and 14.7 a robust one. These results point to a situation in which 20% seem to be at a great risk, while 26% have an incomplete but perhaps manageable preparation. It is obvious that a high proportion of those admitted face a very high risk of abandoning school.

In the next section participants were asked to choose with which statement they agreed more. One option stated that priority should be given to achieving the objectives identified for a course in terms of the quantity and depth of content knowledge. The other phrase said that identifying the quantity and depth of a course's content knowledge is necessary for setting the direction of work with students, but the goals to be achieved in the course have also to consider emergent objectives that appear during the course, given a certain student population. 21% agreed with the first statement and 79% with the second.

In another question of this section, teachers were asked whether they modified their objectives in the light of interaction with students. 79% accepted that they modified their objective, while 21% did not modify them. Again, the same proportion that appears in the previous question taking a traditional type of answer, take a traditional answer here. But, at the same time, it is now clear that a very high proportion of teachers now consciously pay attention in their teaching to what happens with students, in both questions. That is a different situation from the one prevailing in the letters of intention that stated that almost all problems in teaching and learning had to do with what students do not know.

In another item of the questionnaire teachers were asked again with which statement they agreed more. One phrase expressed that generic competences were primordially a prerequisite with which students should comply before they entered university, while the other statement set forth that generic competences should be developed in the university

as part of the general educational process of future professionals. Again the same 79% agree more with the second phrase and 21% with the first.

This pattern is confirmed with the last two sections which asked whether teachers noticed improvements in students' performance and attitudes and whether students perceived the effort being displayed by teachers, and whether their intervention objectives were mostly achieved. A consistent 79% answered positively and 14% answered that the objectives and changes in students' attitudes and performance could not be perceived. It should also be mentioned that those teachers who recognized that some improvement in learning and attitudes took place, also recognized that learning achievements were more modest than attitudinal ones.

Conclusions

The partial results of this project, both regarding the completion of the proposal for a indicative definition of generic competences and the progress made by the project for developing new teaching and learning activities and strategies have so far induced authorities to confirm their commitment to the promotion, in a systematic way, of generic competences. Another partial result that can be contemplated is that in a small but influential sector of faculty a consciousness recognizing the need for collaboration between faculty in charge of science and mathematics teaching in HE with experts in education, didactics and pedagogical content knowledge has now taken hold. This acceptance seemed only a year ago, improbable if not unrealistic.

This collaboration has now to extend to a proposal on the part of the project for a general overhaul of the entrance examination. At the same time, future curriculum reforms now have new referents and experiences to take into account.

On the basis of this new recognition of the importance of interdisciplinary approaches to educational research and development, it is expected that new projects will emerge and disseminate this new sensibility throughout the University, slowly setting the basis for new learning environments. A great challenge remains in the field of improving learning outcomes in students more substantially.

References

- INEE (2012a). *Leer ¿Para qué? La competencia lectora desde PISA*. INEE, México. pp. 3-4.
- INEE (2012b). *El Informe 2010-2011. La Educación Media Superior en México*. INEE, México 2012, pp. 117.
- Narro J., Martuscelli J. & Bárzana E. (2012). *Plan de diez años para desarrollar el Sistema Educativo Nacional 2012*. UNAM, México.
- OECD (2012). *Preparing Teachers and Developing School Leaders for the 21st Century Lessons from around the World*. Edited by Andreas Schleicher. OECD. Paris.
- OECD (2009). *PISA 2009 Results: What Students Know and Can Do*. OECD. Paris.
- OECD (1997). *Reviews of national policies for education. Mexico. Higher Education*. Paris. pp. 105.
- Sexto Informe de Gobierno (2012). Eje 3 igualdad de oportunidades, 3.3 transformación educativa. Available at: <http://www.informe.gob.mx/>
- UAM (2012). *Informe de Actividades de la UAM 2011*. UAM, México.
- Zorrilla J.(2010). *El futuro del bachillerato en México y el trabajo colegiado*. Lecciones de una intervención exitosa. ANUIES, México.

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