ELLINOGERMANIKI AGOGI

EDEN OPEN CLASSROOM 2015

Open Discovery Space Conference

Transforming schools into innovative learning organisations

September 18-21, Ellinogermaniki Agogi, Athens, Greece

CONFERENCE PROCEEDINGS BOOK

EDEN 2015 Open Classroom Conference

Transforming Schools into Innovative Learning Organisations

EDEN 2015 Open Classroom Conference

Athens, Greece

18-21 September 2015

PROCEEDINGS

Including the Collection of "Synergy" Synopses

Edited by

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on behalf of the European Distance and E-Learning Network

European Distance and E-Learning Network, 2015

EDEN 2015 Open Clasroom Conference
Athens, Greece

Published by the European Distance and E-Learning Network

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Supported by the Erasmus+ Programme of the European Union

The publication reflects the authors' view, the EACEA and the European Commission are not responsible for any use that may be made of the information it contains.

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations

The European Distance and E-Learning Network (EDEN) has organised bi-annual Open Classroom Conferences with focus on ICT enhanced open, distance and e-learning, since 1997. The 2015 Conference is addressing the needs in search for Innovation in School Education. EDEN and Ellinogermaniki Agogi are the co-operating partners in organising the three-day international conference in September 2015 in Athens.

Developments in learning innovation and the impact of ICT on school education have presently been realised through many policy actions, programme initiatives and projects. At the same time, socio-economic challenges and the recent, often critical scenarios – social mobility, migration, globalisation, multi-culture structures – change the mandate of what we call Open School Education.

The search for new, more effective school structures, and the overcoming of broader challenges that societies are facing in their way towards the Knowledge Economy, is uninterrupted. The demand is increasing for upgrade of quality, in order to meet the needs for new competences and skills. It is proven that learning personalisation helps foster motivation and engagement, so learning is becoming more and more individualised and self-managed even in institutional settings. The EU has adopted policy initiatives like the Opening Up Education and formulated ambitious goals in the EU2020 programme, for the school education sector as well. Still, most Member States are striving to introduce innovation through resisting structures and hindering factors.

The Athens event is implemented with the involvement and support of significant EU co-funded initiatives, like being the final event of the Digiskills project, which demonstrates ways to involve school communities in innovative teaching and learning practices. Several conference activities will serve as first steps in the sustainability of the Open Discovery Space project, one of the ever-largest EU co-funded educational networking initiatives.

The conference showcases and celebrates the excellence of "change agents" from all over Europe who have developed and improved their digital skills and competences by participating in online and face to face trainings, workshops and competitions.

The EDEN Open Classroom 2015 Open Discovery Space Conference offers an impressive spectrum of different open schooling and teacher training initiatives, major achievements, their resources and training services provided. The conference approach and themes imply openness in choosing the topics and applying interactive session formats.

During the *Scholarly Contributions Sessions*, academics and professionals will present their research and validated practices, following peer reviewed admission process.

András Szűcs
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**Acknowledgement and thanks are given to the
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Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

MOTIONS IN PHYSICS AND MATHEMATICAL FUNCTION IN A WEB INQUIRY BASED LEARNING ENVIRONMENT

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Introduction

We live in an era characterized by the rapid development of technology. Computer science has also invaded the educational process and provides us with many opportunities that we can exploit. On the other hand, an additional challenge faced by STEM teachers is the integration of Inquiry Based Science Learning (IBSL) in teaching. While using ICT has penetrated the inquiry based teaching and learning process, we have to create and implement lesson plans in STEM subjects that promote the cultivation of methodological skills and competencies, investigation through experiment, teamwork and communication among students through collaborative activities. Also the necessities of the active association of Mathematics, Physics, Biology and Chemistry are multiplied and are formulated as desired in the educational process and in the curriculum application. Following and supporting innovative teaching practices this paper presents a proposal of an interdisciplinary scenario in maths and physics in a web inquiry based learning environment using the mathematical educational software (geogebra).

IBSL as a requirement in teaching STEM lessons

IBSL is being promoted in many countries as a pedagogy which improves education. After the publication of the report entitled "Science Education Now: A Renewed Pedagogy for the Future of Europe", IBSL is officially promoted as a highly commended educational objective in all European Program studies (Stylianidou, Koulouris & Sotiriou, 2011 cited in Bybee, Powell & Trowbridge, 2008; Hounsell & McCune, 2003; Minner, Levy & Century, 2010; Rocard et al., 2007). Educational and empirical research offers a wide range of approaches to inquiry-based learning.) According to definition of Inquire Project (Inquiry based Teacher Training for a sustainable future): IBSE is that of multifaceted activities: making observations, posing scientific questions, examining books and other sources of information to see what is already understood, planning investigations, reviewing what is already known in the light of experimental evidence, using tools to gather, analyze and interpret data, proposing answers, explanations and predictions, and communicating the results (Elster, 2012 cited in Linn, Davis & Bell, 2004, p.9). Scientific inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations by finding answers to questions (Elster, 2012 cited in NCR, 1995). IBSL is a pedagogical strategy where the student possesses a dominant role in the learning process. IBSL is often likened as a circle or a spiral, involving the questioning process of creating, research, finding appropriate responses, discussion and feedback in relation to results (Bishop et al., 2004). Educational activities are organized in a circular manner, regardless the topic. Each question leads to the thinking of a new idea and new questions. The educational process through the exploration of the natural or manufactured (simulated) social environment leads pupils to questions and discoveries during which they are searching for new knowledge. With this pedagogical strategy, children learn about science, while they apply those (Aubé & David, 2003).

Interdisciplinary Mathematics and Physics courses in terms to IBSL

Mathematics and physics are developed in a two-way relationship (Manolopoulos & Manolopoulos, 2009) Mathematics and experiment contributed to the tremendous growth of Physics. The great development of physics began in the 17th century with the introduction of experimental methodology and the formulation of laws in the language of mathematics, using equations and graphs. A typical example is the graph theory, a branch of topology, which came from studies of physical problems in the 19th century and recently has applications in natural and social sciences. Gustav Robert Kirchhoff studied electrical circuits and first presented concepts and theorems of graph theory (Mavronikolas, 2002, p.259).

It is assumed that interdisciplinary courses are widely commended to help students acquire the mental agility and critical thinking skills needed for success in the modern world. Recent literature catalogues the benefits believed to accrue from interdisciplinary courses. These courses will show students how to address complex issues and help them think more critically (Korey, 2002 citied in Newell, 1994; Davis, 1995; Klein, 1998; Rhodes, 2001). They will encourage faculty to be pedagogically adventurous, promote the synthesis of knowledge, and help to draw the campus community closer together (Korey, 2002 cited in Austin & Baldwin, 1991; Davis, 1995, Rhodes, 2001). In mathematics and sciences, they will increase student interest by relating those fields to other accessible and engaging questions, and they will increase student numbers by attracting students from outside the traditional mathematics and science majors (Korey, 2002 cited in National Science Foundation, 1996; Ganter & Kinder, 2000).

Inspiring Science Project: Web Inquiry learning environment

Merging mathematical and scientific approaches in terms of using digital tools and interdisciplinary working methods is an additional key characteristic of IBSL. There has been substantial evidence over the last several decades that web-based learning interventions have positive effects on student learning outcomes (Allen & Seaman, 2010) and student engagement (Chen, Lambert & Guidry, 2010). The portal of Inspiring Science Education (ISE) project has developed the technical infrastructure for designing and delivering technology enhanced interdisciplinary lessons following IBSL (Zervas & Sampson, 2015). Educational scenarios or lesson plans include a widely used inquiry learning model, the 5E Model, which lists five inquiry phases: Orienting & Asking Questions, Hypothesis generation and Design, Planning and Investigation, Analysis and Interpretation, Conclusion and Evaluation (Zervas & Sampson, 2015). Each phase of the inquiry cycle includes a set of inquiry activities:

ISBN 978-615-5511-06-6

- Digital educational resources of any type (text, images, videos);
- External digital educational resources stored in the ISE Portal;
- External digital educational tools stored in the ISE Tools Repository;
- Guidelines/notes for the teacher to implement the inquiry activity;
- Assessment tasks to assess students' knowledge and provide feedback;
- Teachers should be able to add at the end of each inquiry phase appropriately (Zervas &Sampson 2015).

Assessment problem solving (PS) competence as measure of effectiveness of inquiry-based learning

Problem-solving competence is an essential component of the skills required to perform interpersonal and no- routine analytic tasks successfully. In both kinds of tasks, workers need to think about how to engage with the situation, monitor the effect of their actions systematically, and adjust to feedback. Thus, in each phase of the lesson plan ISE platform there are two questions of PS in order to support teachers to be able to measure (among others) the effectiveness of IBSL. While schools are not the only environment in which problem-solving competence is nurtured, high-quality education, in a wide range of subjects, certainly helps to develop these skills. Progressive teaching methods, like problem-based learning, inquiry-based learning, and individual and group project work, can be used to foster deep understanding and prepare students to apply their knowledge in novel situations. Good teaching promotes self-regulated learning and met cognition – particularly knowledge about when and how to use certain strategies for learning or for problem solving – and develops cognitive dispositions that underpin problem solving. It prepares students to reason effectively in unfamiliar situations, and to fill gaps in their knowledge by observing, exploring and interacting with unknown systems. (Assessing Problem-Solving Skills in PISA 2012; Creative Problem Solving: Students' skills in tackling real-life problems – Volume V, OECD 2014 p.29)

Mathematics educational software as digital tool of supporting interdisciplinary courses and IBSL

Teaching physics and mathematics in classroom should not be limited to the transmission of knowledge of each subject, law in physics and algorithmic equations in mathematics, but teachers should give to the student multiple possibilities for the cultivation of critical thinking, creativity, spirit of research and exploration and self-motivation. In traditional teaching, the lack of appropriate multiple representations of concepts does not allow for deeper conceptual understanding of the science's role in real life. Instead, the use of educational software as geogebra in STEM education improves interdisciplinary teaching approaches and introduces new forms and opportunities for learning. Geogebra software by introducing changes (runners) allows dynamic change and transformation functions in graphic representations. In this way the teaching of movements in Physics can be connected to the properties of graphical representations of functions in mathematics. Geogebra offers many representations of understanding scientific concepts. Students experiment by changing the variables and

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parameters of the experiment, but simultaneously they could observe the graphical representation of these changes. The justification of changes through graphic representations enables students to give reasons and draw conclusions based on mathematical knowledge.

Short Description of scenario on the ISE portal

Orienting and Asking Questions

Concepts in motions: Understanding vector representation of velocity, acceleration, movement.
Photos and questions on which students make calculations and discuss contents with basic conceptions of linear motion i) constant velocity ii) constant acceleration.

↓

Hypothesis Generation and Design

i)

Movement (x)	Time(t)	Velocity(u)
20	2	
40	4	
50	5	

-Mathematical Function that describes the motion with constant velocity in linear movement: f(x)= u*t
-Creation of graphical representation.
ii)

Velocity(u)	Time(t)	Variation in velocity	Variation in time	Acceleration a
10	0			
16	2	16-10	2-0	$6/2=3m/s^2$
25	5	25-16	5-2	$9/3=3m/s^2$
40	10	40-25	10-5	$15/5=3m/s^2$
100	30	100-40	30-10	$60/20=3m/s^2$

-Mathematical Function that describes the motion with instant acceleration in linear movement: f(u)= a*t
-Creation of graphical representation.

- Students make hypotheses and connections between properties of motions that are presented in the value table (form of motion in algebra) and their graphical representation.
- Students correspond the form of motion in algebra and then design their graphs models

↓

Planning and investigation

- Using properties of educational software students investigate the graphical representation of motion, while they changes values to variables :x, u, a ,t
- Students correspond the graph model with the mathematical function of motion.

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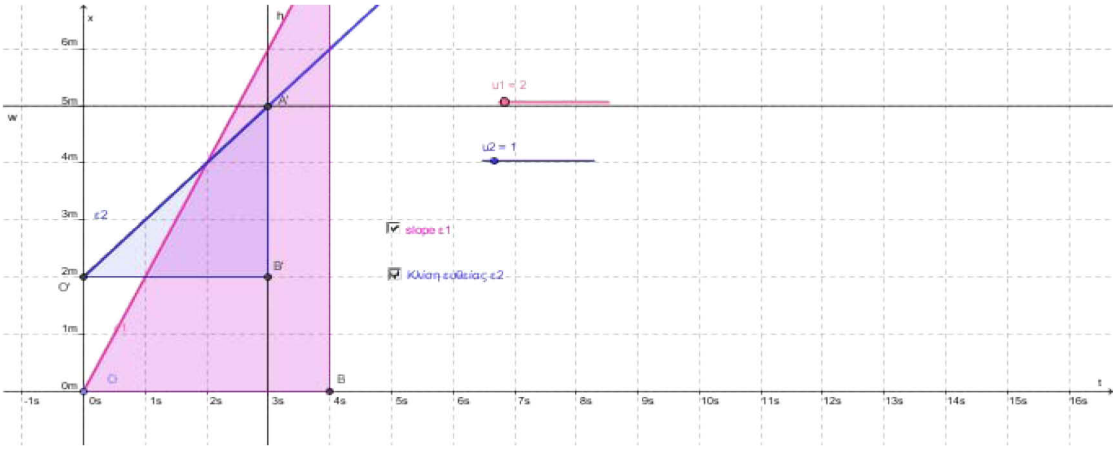


Figure 1. Graph representation of movement x and time in linear motion with constant velocity

Questions:

The linear (above) are the graphical representations of two motions. Complete the value table in motion 1 and then in motion 2. Create for each case a value table of movement x and t from pair of values in graphs.

- Calculate the rate value x / t for each column in both cases and the slope of the lines 1 and 2. What do you notice?
- What are your conclusions about their movements and what mathematical function (relationship) can describe the change in x-t;
- If we vary the value of speeds u1 and u2, what changes occur in the corresponding graphs? Explain.
- Calculate through the graph the space that has been covered in 1 from t = 0 s until t = 3s or t = 5 and t = 10. Also, calculate the distance by equations of physics in the graph movement from t = 0 s until t = 3s or t = 5 and t = 10. What do you notice?

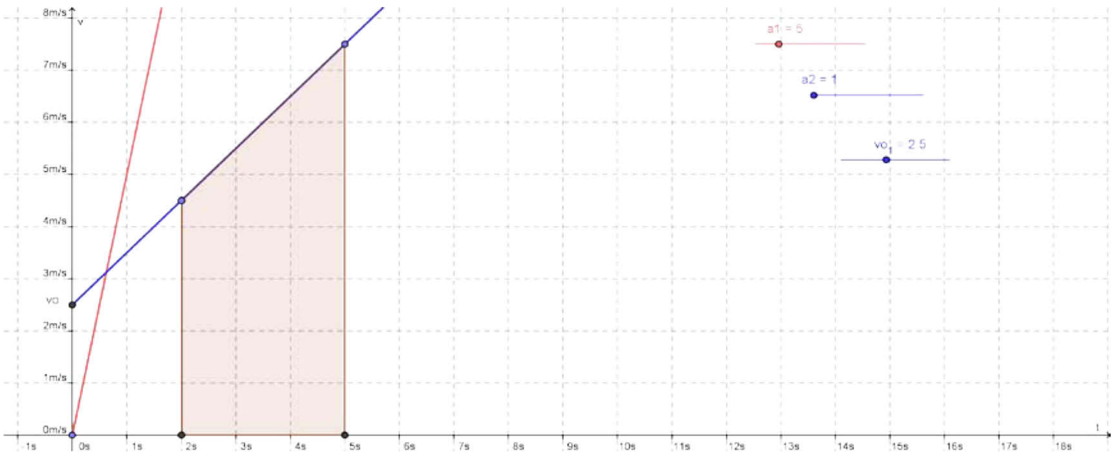
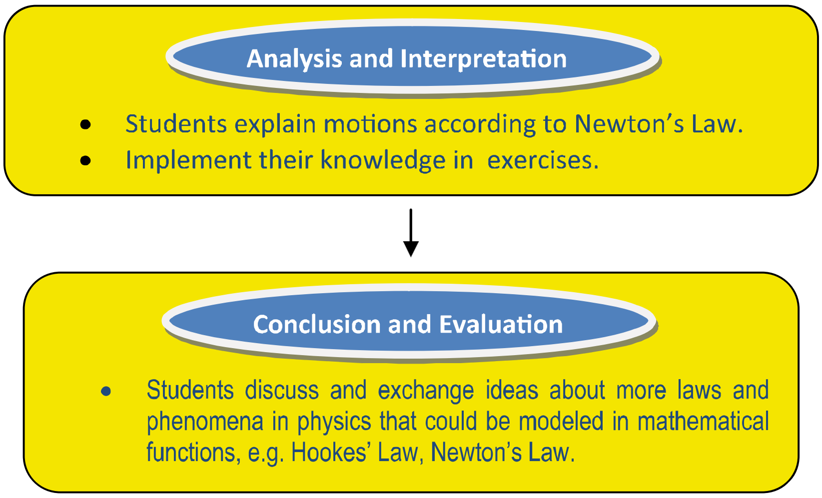


Figure 2. Graph representation of velocity u and time t in linear motion with constant acceleration

- What difference do you notice in graphs 1 and 2?
- Calculate the slope of the lines 1 and 2. What do you notice?
- What mathematical function (relationship) can describe the relationship of u-t;

ISBN 978-615-5511-06-6

- Write the equations of motion in each case and compare them with functions of question 3.
- Change the value of accelerations a1 and a2 or the initial speed uo1, what changes are observed in the corresponding graphs? Explain.
- Calculate through the graph the time that the two bodies of motions will meet.
- Confirm your calculations with algebra. (Solve the equations of two motions)
- Calculate through the graph the space from t = 3s until t = 5s.



http://tools.inspiringscience.eu/delivery/view/index.html?id=aa05d6be9ae34239929a0a1772749f5c&t=p

Conclusion

In this paper I have tried to answer two basic questions: "How can we induce motivation for learning mathematics and physics and in general science?" and "how can we eliminate students' negative attitudes towards this? As STEM teachers, we have to use ICT in order to find new ideas and experiences aimed at the development of an all-round personality of young people. The context of IBSL incorporates innovative strategies such as active learning and students are encouraged to take their own responsibility for their learning, develop their own meanings and construct their own knowledge. The integration of interdisciplinary and experiential approaches are two key pedagogical principles that teachers need to take into account while scheduling their way of teaching. Mathematical educational programs rely on the basic pedagogical and didactic principle according to IBSL, that learning is better when incentives and interest are created in learning. In the context of innovative teaching approaches are dictated by the curriculum chosen as the subject matter of interdisciplinary mathematics and physics. Finally, there should be a web learning inquiry environment active and constructive participation of the student in activities that demand efficient and flexible strategies and in addition, they help them understand and think logically in activities which set their own learning goals and help them correct their mistakes.

ISBN 978-615-5511-06-6

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

IMPLEMENTING INNOVATIVE LEARNING METHODS: A TWO SCHOOLS EXAMPLE

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Abstract

Applying new innovative learning methods in schools can strongly influence and reform them. Schools are vital organizations adequate under constant changes, reformations and developments. Teachers, students and parents, all contribute into these changes materializing educational envisions. We strongly questioned ourselves how these innovative educational approaches can influence and reform an urban and a rural school respectively. We selected an urban, Model Experimental School and a typical rural High School in Greek countryside. We applied almost the same innovative approaches to both schools inquiring gradually the out coming changes. In the case of the urban school new education methods were necessary to be applied in order to raise students' interest, entangle them into educational practices that are not so font of and reduce school abandoning. On the other hand applying almost the same practices to an Experimental School has to do with its fundamentals and basic principles. Students attending a Model Experimental School were chosen after exams and are in general willing to take part into educational programs, excellence groups, experimental workshops, exchange mobilities and other innovative projects. Although, we founded that the rural school reformed rapidly into a highly developing school, achieving gradually some of its pronounced educational goals. Teachers' and administration's vision began by encouraging teachers to participate into educational meetings, conferences and developing courses. Additionally, groups of students were organized to prepare several projects according to their interests. We can mention the Astronomy group, the Environmental group and the Drama group. Accordingly, we invested on extroversion and presentation of projects. Astronomical and Environmental events and Drama performances were some activities that joined the rural school with the local society, parents and communities. Furthermore, students revealed a remarkable interest about sciences and culture. On the other hand at the Model Experimental School, all these activities regarded as standard activities, sometimes as obligations. Of course also this school had some remarkable educational programs, interesting experimental workshops and extroversion to the local community. What differentiates the Experimental School is its excellence groups, were teachers and students are approaching non typical subjects of Science, Art and Culture. These groups seem to be the comparative advantage of the urban school leading to extra-curriculum knowledge. In any case the urban school seems to develop and reform itself, but not as fast and crucial as the rural school.

Introduction

We are witnessing a new social capital where knowledge and learning are the result of cooperation and interaction of people, with master trust among participants, social networks, linkages and partnerships based on the social values of society (Kalantzis & Cope, 2013). "The new learning is reflected in the concepts of transformational, integrative and cooperative education mainly of the Social Gnosticism, of the state pluralism but also of the principles of reconsideration, cognitive repertoires and synergistic feedback» (Arvanitis, 2013, p.19). It is therefore clear from the above that the issue of us as educators, it is now shifting from the teaching of the subject, in teaching the active subject, where the meta-modernism, i.e. the affirmation and acceptance of pluralism and integration of the personal style, has the total power in learning practice (Kossyvaki, 2003). Furthermore, some dogmatic concepts of objective and indisputable knowledge and the acceptance that knowledge is consider as a social construction adequate under continuous trading, alongside to the circular organization of living systems that self-regulated entities in interaction with the environment, are required to be abandonment (Kossyvaki, 2003, p.44). Schools which purport to stand at the forefront of the education system should at least work pluralist in its choices of educational methods used. As teachers we are called to respond and to rebuild the context of the educational process. The student turns from passive to active receiver underlying learning and teachers must abandon the role of authorities (Kossyvaki, 2003), by developing the necessary skills that will give it the ability to cope with a world that is constantly changing. Additionally, compelling is the need for using alternative forms of education that will offer good education for students who for whatever reason cannot participate in the conventional system of education. Teachers must prepare their students, integrating the life skills that will enable them to recognize and manage a world that is constantly changing.

Practically, how can we organize and reform a rural school? Designing a long period action plan can help a school? How can we implement theoretical predictions into real school environment and evaluate our findings? It is well known that teachers have to participate into educational conferences and courses (Baird et al., 1991). Meetings and courses are crucial for the overall progress and development of teachers (Shannon et al., 1998). New trends in education had to be spread into a rapidly changing world (Tillema, 1994). Modern educators and teachers are expressing a growing demand for lifelong learning programs (Hobson, 2002). Additionally, all new trends must be implemented into classrooms and embodied in the traditional curriculum (Helsby, 1995). In parallel students must accept and incubate modern pedagogical methods (Finn, 1998). Working in groups, consisting working teams, preparing projects and presenting results are some of the new aspects of education. On the other hand, excellence groups (Howley, 1989) and students' contests (Verhoeff, 1997), seems to gain an important part of nowadays educational system. Furthermore, extroversion of knowledge gradually becomes a goal for many schools (Holland & Andre, 1987). Astronomical and environmental events (generally science courses), cultural performances (theatre) are of high educational content. But the question is how we can implement all these aspects into daily educational practice.

ISBN 978-615-5511-06-6

Implementation

The two schools, on whose actions we rely on to develop our thoughts and with whom we have engaged either as Headmasters/mistress or as teachers, tried to implement a knowledge management program aimed at achieving specific learning outcomes such as the diffusion of knowledge, the improved performance, competitive advantage in a public school and high levels of learning innovation. So through the exploration and implementation of pre-existing knowledge trying to create new knowledge for our students and ourselves, always having in mind that in any educational application, learning as a product of the learning and not just teaching (Lionarakis, 2006). At the same time we took seriously into consideration that learning is not only cognitive development but depends heavily on the feeling, the will, the drive and the "physicality" (Kossyvaki, 2003). The Knowledge management model we rely on in order to design our educational plan for both schools was that proposed by Collison and Parcell (Collison & Parcell, 2001), considering three basic knowledge management elements: people, technology and procedures. At the same time we received seriously in consideration the pro-mention theoreticians' opinions about the crucial role of the schools' culture in every single case i.e. the differences between the culture of the rural and the urban school.

Thus we tried to set the bases for creating schools with teachers and students as an integral part of the "knowledge society", exploiting creatively knowledge which occurs outside the classroom and implementing the so called "School on cloud". Schools that are familiarizing students with inquiring, managing and extracting the information, pull down the watertight boundaries of disciplines and interdisciplinary approach knowledge, involving diversity in learning and finally teachers that try to get out of the suffocating confines of Marxist "alienation" of alienation that is the product of his labour. The four axes of the action plans that were formed were:

- the logistical equipment and improvement of building infrastructure,
- teachers training and engaging with new pedagogical data, innovation and research,
- improving teaching instrumentation aimed at developing students skills that will ensure a smooth, balanced and productive path in their integration into society and the labour market in particular and finally,
- evaluation.

In both schools we have mainly problems on rising students' interest, provoke curiosity, but especially in the rural school we have also some disciplinary matters. Both schools wished to develop extroversion and come closer to local communities. According to these major needs in both schools we based on lifelong learning, implementation, group working, production of educational material, extroversion, seminars, educational and cultural events, participation in contests, evaluation and feedback.

ISBN 978-615-5511-06-6

Urban School activities

The goal for improving the education provided includes actions related to the Organization of the school community as community learning, developing educational material relating to the curricula of the new school and the pilot curriculum and designing teaching methods as set out in the institutional framework (Kalantzis & Cope, 2013). Initially the improvement of education in a public school requires in-service training for teachers. The drafting of a questionnaire on the training needs of teachers and the exploitation of the data helped in the planning of training activities under the supervision of School Counsellors and properly design seminars and projects. Furthermore we designed training activities in cooperation with Universities, other educational institutions but also through applying and succeeding an Erasmus+ proposal for Certified In-Service Training Mobility Program for the school staff: The proposal indeed provides a summer school for teachers as an implementation activity.

Additionally, we signed protocols of cooperation and development of partnerships and actions with Universities or other educational institutions while our connection with the local community formed the next long-term goal. In particular the cooperation protocols were signed with the Laboratory of Educational Material and Educational Policy of the Hellenic Open University (HOU), The Laboratory of Research and Mathematics Teaching of the Department of Primary Education (University of Patras), department of Telematics Applications and Regional Development of Computers Technology Institute CTI and Technological Institute (ATEI) of Patras. With all the above institutions have developed actions involving both students and teachers or students and has been planning for the full development of cooperation in the coming years. At the same time is in process the signing of protocols with School of Pedagogical and Technical Education (SPETE), the Laboratory of Sociology, Educational Research and Professional Development of the Department of Educational Sciences and Education in Preschool Age (TEEAPI) and Science Centre of Patras. At the same time we also formed partnerships with other local and international bodies. The opening of the school in the academic arena but also in society in general resulted in the change of the mentality of educators and further enriching and updating the curriculum.

Regarding the digital school equipment, we pursuit potential sponsorships, while significant turned out to be the volunteer work by teachers. As a result of these actions we can refer that our school was equipped with the latest technology machinery and two computer laboratories where each pupil has his computer, the development of excellence clusters of Robotics with four available robots. Furthermore we equipped all classrooms with computers and video projector in well accordance with installation of optical fibre connection and the possibility of developing high speed Internet in every classroom or lab. These were important steps towards upgrading the quality of the learning process and practice while at the same time gave us the ability to design and implement innovative actions. In addition to the adopting of teachers Learning Content Management Systems, which will allow them to create a Web module, was one of the components of the future design of the learning process.

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The curriculum of the Pilot Schools (Including Model Experimental Schools) allows educators and teachers to produce educational material utilizing interdisciplinary approach. Indeed until now we configured important educational material that is posted on the website or in our "school in cloud". Shaping interactive online class from all teachers is the next challenge. It is worth noting that where applied online class or online educational platform the number of visitors was overwhelming. Alongside the order constituted an important part of the curriculum which was implemented this year, another major innovation was the seven clusters (groups) of excellence, innovation and creativity that functioned with the participation of about 150 students (out of 180). In addition, all students and teachers of the school were involved in experiential synthetic work. Pupils and teachers had to remain at school after completion of the course in order to implement these activities. The consistent presence of the students and the almost non-existent, leakage is a positive feedback for our effort but simultaneously creates higher expectations to which we must respond with the unique reward of taking care for our students and their parents. It is important to stress that all these actions and other innovative measures undertaken by individual teachers followed a prescribed procedure dictated by the principles of modern pedagogical-educational movements, as well as specific instructions and instrumental approval of the Scientific Supervisory Committee (EPES).

Finally we must mention the importance of the evaluation process of the action plan and educational work of the school in general. It should be noted here that both the excellence groups and the actions initially involved in the original design their valuation and deliverable material – after their completion-all deliverables, educational tools and results of assessment were filled out. In the final meeting of the Plenary Session of Teachers but also in the Scientific Supervisory Committee (EPES) meeting where the theme of the evaluation of curriculum and the actions of the school year were discussed, we concluded that the process of feedback is very important in order to further proceed into decision-making for the remodelling of the stages of the learning process that did not worked effectively.

Rural School Activities

First of all in order to face the problems we realized that teachers had to be educated and trained on new pedagogical and didactic trends (Day, 1999). Teachers were encouraged to participate to several training and learning activities. During the first stages of our action plan teachers were educated mainly on new education trends, educational scenarios, ICT implementation in classrooms, modern pedagogical trends and new approaches in daily school life. It was clearly understood that traditional pedagogical methods were inefficient. On contrary whenever a new pedagogical method was applied a rising interest was observed. Teachers also appear more willing to test new approaches. As a result of all these activities we realized how important is for educators to attend training activities and programs. New prospective occurred and new methods applied in classrooms. This was the first step of a school that learns, evolves and develops.

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Secondly, teachers were encouraged to produce educational content. Educational scenarios were developed, learning materials ware produced and working groups organized. We introduced and encouraged a new innovative idea of organizing student groups with special skills and responsibilities (Johnson & Johnson, 1990). For example, the Event Organizing Group, the Promotion Group, the Media (e.g. video) Producing Group, the Drama and Astronomical Team were some of the most active groups. We uploaded most of the produced educational material and scenarios on electronic means (e.g. our website), while the working groups started producing projects and events. A group of teachers was responsible for each working group. They were setting final goals, organizing their working plan, scheduling meetings and evaluating their progress. We tried all steps of the working groups to be based on educational scenarios. This parameter was also an important aspect of a constant learning school (Schank, 1994). We detected and evaluated all steps, extracting important conclusions of how a school can become a working community. Additionally, the educational material and scenarios seem to encourage students to further search for knowledge. As all this educational materials were available on the web, educators and teachers found additional teaching tools.

Excellence and Contests

A second step to our action plan was excellence, focusing mainly on contests (Bishop, 1991). We realized that participating on National or International Contests was really a unique opportunity to raise the interest and competiveness of our students. We can refer to the most successful attempt, the "Odysseus" Contest. This contest was about Astronomy and co-evolution of life in space. Winning the contest was not our initial goal; instead we were mainly interested on developing a progressive educational pathway (Jacobson & Wilensky, 2006). First of all we organized a team consisting of almost ten students interested in Astronomy. We scheduled some standard meeting dates, but we met each other mainly out of schedule. Because of the strict school curriculum we had to communicate a lot through electronic means (e.g. Skype). All these state problems and aspects are interesting parameters of how a school learns to work in groups, communicate and develop a project (Garmston & Wellman, 2013). We learned that ICT are absolutely necessary tools for education.

Astronomical Event

Developing our Astronomy project, we realized that we needed some hands on experience, observation knowledge and support by experts. These realizations were important on organizing the first Astronomical event in our school's region open to local community. The event was a result of an excellent collaboration between several working groups, teachers and authorities. The event-organizing group supported the whole action, the promotion group, the media group and astronomical team also took great responsibilities. Teachers from our school participated in several parts of the event, while we had the support of the Municipality of A. Olympia and the 7th Ephorate of Prehistoric and Classical Ancients (EPCA) of A. Olympia. We operated remote telescopes from distance, a professor from University of Patras gave Lecture about the Universe and finally we observed astronomical objects by telescopes. All these activities raised the interest of students and revealed a new orientation in learning

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procedure for our school. Local communities and authorities came closer to our school and we learned how to expand our audience (Hanifan, 1916). We had now a strong team willing to work harder for our contest project.

From this point and on the final title of our project was clear. We decided to work on plants attitude and colour on another planet. The contest's demand was a clearly defined scientific question, fully developed and answered through experimental and bibliographic justification. Although the difficulties, we managed to win the National part of the contest on March 2013 and the European part of the contest on April 2013. Of course this was the first step of a working methodology. Although it seems that our main goal was the win of the Contest this is not absolutely accurate. We initially tried to intrigue and provoke students to take part to all the related activities. It was the same with the participation of an environmental Contest and also with the drama performances of our school. Furthermore, we realized that extroversion events are extremely important for the educational practice (Elmore, 2007).

Environmental Event

We followed up with an environmental event, which was actually an ecological meeting. This event combined lectures by professors of the University of Patras (another important parameter is growing a standard collaboration with higher education foundations), hands on activities (experimentation related to chemical effects on environment), speeches by market representatives and groups of volunteers. This was also an open event to local community. Apart from this aspect students learned many about connection between education and market especially on the agricultural field (Clark, 1983). Additionally, volunteerism presented to students as a part of environmental protection part (Goldberg, 1998). All these aspects were highly educative for students and local community, while a rural school approaches the day life of local society (mainly agricultural) from many aspects (scientific, economic, activism). On the other hand this was our second extroversion event. Our working groups continued developing and performing even more professional. Doubtless an important parameter of the constant learning school is assigning important responsibilities to students (Ames, 1992).

Innovative Approaches

In parallel we introduced some innovative approaches in every day teaching practice. Real time (synchronous) video conferences were implemented on several lessons (Murphy & Coffin, 2003). An interview from the researcher Michael Tsambas at Lyon France and a couple of virtual visits to CERN were some of our distant learning attempts. Additionally, we increased the use of ICT on daily teaching practice. Whole lesson were presented digitally, while experiments were combined with electronic means e.g. we used augmented reality applications (Kaufmann, 2003) and Kinect camera for detecting movement and air presenting (Hsu, 2011). In all these actions students' working groups organized almost the whole activities. We realized that students were feeling important in participating actively, while they count the success of the event as their personal success. This is also a remarkable point as we often focused on students with low learning expectations but exceptional technical skills giving them responsible roles on all events Furthermore, we also gained important profits on

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the disciplinary section. Students felt that a well-organized and extrovert school is not only a matter of strict rules and punishments, but mainly a school that develops healthy relationships between all members (students, teachers, parents, local community).

Conclusions

As far as concerns the Urban School, which is actually a Model Experimental School we can assume that the institutional changes that have occurred in the operation and administration of the school, created the certainty of a positive climate of cooperation and participation in educational matters. A climate that is indeed inherent in public schools, but its development impinges on bureaucratic mechanisms and regulatory frameworks. At the same time the present State Control Mechanisms in Education that transforms educators and teachers into forwarder civil servants, are strongly forced to change form. The latter is not painless or easy, requires a change in the way of facing the concept of "participation", something that may eventually be dangerous for the system. The possibility of a learning unit to utilize its experience and develop culture of innovation is what matters in a society that is constantly changing, changing us also in parallel. At the same time the implementation of an action plan based on respect of the educational and vocational development targets and the simultaneous creation of mechanisms of communication and collaboration with students and the wider social and educational context, could lead in the near future to transform us into thinking school. We strongly believe in a school that learns from its imperfections, his mistakes and the new comings, but his vision remains a collective creation and constant pursuit.

On the other hand the rural school concluded, according to its action plan, that first of all it is of high importance, schools to organize and plan their actions in long term (Sniehotta, Schwarzer, Scholz & Schüz, 2005). We realized that planning a three or four years plan will be absolutely beneficial for achieving goals and upgrading educational practices. This also reveals that an essential evaluation can only be performed after a long period (3-5 years) of actions and activities. Secondly we confirmed the importance of lifelong training for teachers and educators. Doubtless, participating in educational seminars, conferences and training meetings allow teachers to be always informed about new educational trends (Day, 1999). Implementing all these compulsory methods in classrooms turns out to be extremely positive for students. Furthermore, organizing extroversion events by entrusting critical responsibilities to students was also one of our positive remarks (Elmore, 2007). We observed that all these events joined teachers, students and local community together. Science and culture came closer to students and local society, while the interest of students rose remarkable. All these events include the element of collaboration and cooperation between several partners and promote our basic goal of knowledge diffusion. Additionally, participation in contests is another crucial parameter (Bishop, 1991). Healthy competiveness between students and schools can only offer benefits to all participants. Winning a contest is not the key. We are mainly interested in the whole progress and steps of contest. We wish students to take part, work, and search, compose papers and support publicly their projects. Of course a won contest satisfies students and encourage them for new tries. Another remarkable conclusion is the importance of educational scenarios, material and content

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(Jacobson, 2006). All these produced objects are really useful for planning and orienting bigger action plans. Furthermore if all these educational objects are uploaded in websites, everyone can easily access and use them. Finally, we can claim that each step was an evaluated progress of a previous one, helping us to achieve goals and milestones. This is how a school learns by itself and by others.

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

SCIENCE TEACHING IN SECONDARY SPECIAL EDUCATION

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Introduction and Background

Since 2009 (http://4myfiles.wordpress.com/?attachment_id=67) “hands-on” activities with “low-cost” materials (Κουμαράς, 2002; Valadares, 2008) were integrated in Science Education didactical approaches (Figure 1) and were found to be a useful approach[1]. Since then, various educational tools have been deployed in science education maximizing students’ educational outcomes. Nevertheless, the most fruitful “tools” for teachers are collaboration, experience gained after participation in face to face trainings such as a summer school and the interaction with colleagues from all over the world in online communities of practice. All these were achieved with involvement in ODS, GreeNET, ISE, GoLab projects and competitions, which also led us to collaborate with other educational “frameworks and initiatives”, such as Universal Design for Learning (UDL)[2] and the UDLnet Network, that will be presented in the following sections. This paper presents, shortly the didactical proposals awarded in Pathway, GreeNET, GoLab, ISE contests as well as the approach documented as one of UDLnet Practices.

Figure 1. Hands-on activities with low–cost materials, school years 2009/10 (left) and 2012/13 (right)[3]

[1] It is also our strong belief, that experiments with simple materials “weld” the scientific knowledge and understanding of the scientific ideas to everyday life experience and the content of the scientific ideas respectively. These experiments reinforce the learning benefits of teamwork models, of learning, of investigation, of differentiated instruction and are a very important component in creating a positive climate in the classroom (Κουμαράς, 2002)

[2] http://www.udlnet-project.eu/ & http://udlnet.di.uoa.gr/

[3] https://4myfiles.wordpress.com/pstr/physics/

The educational activities presented target students from mainstream education as well students with disabilities and/or special educational needs (SEN) (Riviou et al., 2015; OECD, 2015). To plan lessons in special education one primarily have to take into account: i) students' difficulty to connect core scientific ideas and mathematical representations (Παντελιάδου, 2000; Παντελιάδου et al., 2004), ii) students' concepts are universal and not easily modifiable (Driver et al., 1994;Περδίκης, 2006; Heywood & Parker, 2010 [4]) and iii) students' difficulties regarding memory (short term, working, long term) (Μπότσας, 2007). In order to achieve our educational objectives we integrate the Big Ideas of Science (GoLab, 2015), Inquiry Based Science Education (IBSE), metamemory strategies (Karably & Zabrucky, 2009), posters as educational materials (Nerantzis, 2014a), analogies (Περδίκης, 2006), Information and Communication Technology, online repositories of educational resources such as Inspiring Science Education (ISE) and GoLab. The educational activities are available online on the blog of the first author: https://4myfiles.wordpress.com/ and on the corresponding repositories. The educational process followed "negotiates" basic concepts of physics (such as *field, energy, gravity*) with tools which always move students' curiosity. Therefore, open inquiry (Levy et al., 2011) via an Inquiry Spaces Learning (ILS) approach is providing internal motivation to students (Boekaerts, 2002). Our educational objectives are from the Bloom's revised taxonomy (Heer, 2012) and refer to a process of teaching as a necessary means to an end (Staver, 2007). We envisaged the active involvement of all of our students in order to understand the basic scientific concepts (Staver, 2007), and set our educational goals in the zone of proximal development (Vytgosky, 1978).

A didactic proposal to introduce the concepts of "energy flow", "wave", "oscillation" and "disorder". (Νεράντζης et al., 2013) – Pathway project

The didactical proposal was awarded with the 3rd prize at IEP's / PATHWAY's contest on IBSE entitled "The Pathway to Inquiry Based Science Teaching" (266624/SiS-CT-2010)[5].

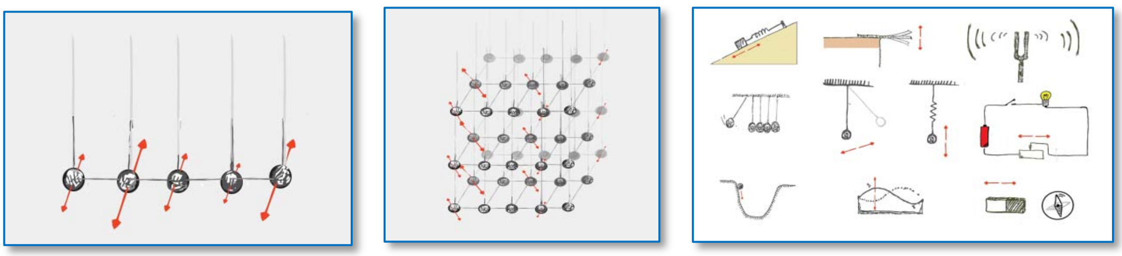

Figure 2. 1D joined pendulums (left), 2D & 3D joined pendulums (centre) and experimental setups (right)

[4] Moreover, «there appears to be no study which found that a particular student's conception could be completely extinguished and then replaced by the science view. Indeed most studies show that the same old ideas stay alive in particular contexts. Usually the best that could be achieved was a 'peripheral conceptual change' in that parts of the initial idea merge with parts of the new idea to form some sort of hybrid idea» (Heywood & Parker, 2010).

[5] see http://pathway-event.ea.gr/ & http://pathway-event.ea.gr/pathway-resources, It is the result of the collaboration and support on such initiatives from the Serres' Consultant for Science, Aik Mpezergiannidou, and the responsible of the Serres' Laboratory Center of Science (LCS), S. Mandiliotis.

ISBN 978-615-5511-06-6

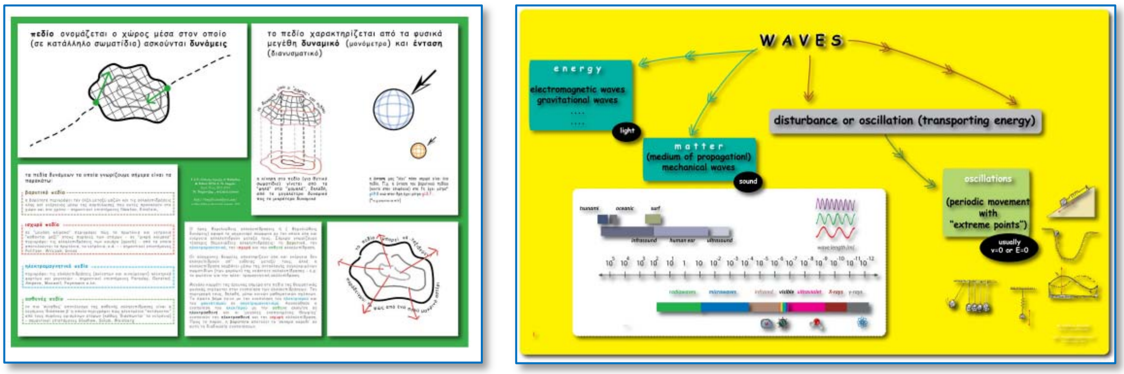

Figure 3. Posters on fields (left) and waves (right) (https://4myfiles.wordpress.com/pstr/physics/)

The "7E" IBSE model has been used: elicit – engagement – exploration – explanation – elaboration – evaluation – extend (Levy et al., 2014). The proposal is supported by three (3) worksheets – one for every didactical hour (http://wp.me/p3oRiZ-1R). The scenario includes the "water cycle ≈ DC electrical circuit" and "matter ≈ energy" analogies, energy chains (Nerantzis, 2014b; Tiberghien, Baker & Brna, 1999), storyline (Ηλιοπούλου, 2006; Solstad, 2006), scientific questions and experimental inquiries on flow(s), wave(s), oscillation(s) with experimental setups and 1D, 2D and 3D pendulums (Figure 2), posters (Figure 3), ICT. The activities proposal can be found also on UDLnet inventory[6] (Riviou et al., 2015).

On simple DC circuits (Nerantzis, 2014c) – GoLab project

This didactical proposal was awarded with the 1st prize to 2014's GoLab's national teacher contest[7]. The scenario includes the educational use of comics (Kakalios, 2009), the Electrical circuit lab (the former Electricity lab)[8], experiments with "low cost" materials, the use of smart-phone and/or tablet for initial and final wireless recording students' responses (Πιερράτος, 2013; Πιερράτος, et al., 2014), the use energy chains and charts. The primary idea was to emphasize the "dialogue" between reality (hands-on experiments) and models (virtual laboratories). As the use of models is very broad (Ginnis et al., 2010) and necessary in science, all students are invited to recognize the ideality of the model, while understanding the limitations of such simulations in the display and interpretation of real world[9]. Additionally, students will work in simple DC electrical circuits and they will extract relationships between physical quantities. They will also recognize energy conversions and transfers. Students will work in groups with both the virtual laboratory and the "real" laboratory. Finally, as optional, there is a third lesson plan using the "electrical circuit – traffic road" analogy (Figure 4). You can find the three (3) associated Inquiry Learning Spaces (ILS) here: http://wp.me/p3oRiZ-80. This didactical proposal was implemented at the Inclusion Class of 4th Junior High School of Stavroupoli (Thessaloniki, Greece).

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[6] …
[7] http://golab.ea.gr/contest2014/content/contest-winners
[8] http://www.golabz.eu/lab/electrical-circuit-lab
[9] Υπουργείο Παιδείας & Πολιτισμού, Παιδαγωγικό Ινστιτούτο Υπηρεσία Ανάπτυξης Προγραμμάτων, Πρόγραμμα Σπουδών Φυσικών Επιστημών για τα Δημοτικά σχολεία και Φυσικής για Α' Γυμνασίου - Α' Λυκείου για τα Γυμνάσια και Λύκεια της Κυπριακής Δημοκρατίας , ISBN: 978-9963-0-9115-7, 2010 .

ISBN 978-615-5511-06-6

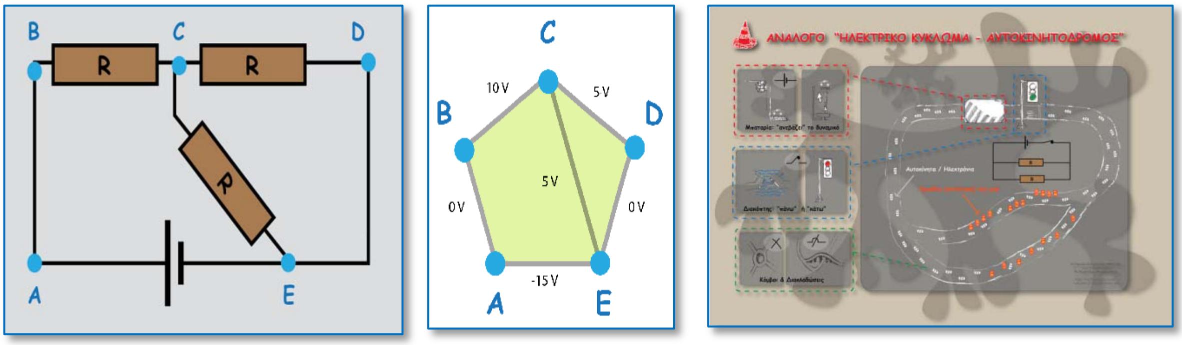

Figure 4. A simple DC circuit (left), its "circuit's polygon" (centre) and poster on "electrical circuit ≈ traffic road" analogy (right)

Experimental (open) inquiry with low-cost materials, on the simultaneous freefall of two different bodies from the same height[10] *(Nerantzis & Mandiliotis, 2014) – GoLab project*

The implementation of this didactical proposal was awarded with the 1st prize of the 2015 GoLab national contest[11] and the award was the attendance of the 2015 GoLab summer school. The activities were implemented in two classes (the 2nd & the 4th) of the Special Vocational High School of Serres[12] (http://wp.me/p3oRiZ-bY).

To study the free fall many teachers have developed some very interesting educational experimental setups and activities using ICTs and robotic applications (e.g. Arduino[13]). The initial idea (spring of 2013) included a more "complicated" device to "jam" of electromagnetism but eventually a "simple" device was chosen. For the implementation of this activity the use of cameras and/or smartphone and/or tablets and photo editing software and video is "required". Many pages are written on Galileo's experiment of throwing balls at the Pisa's tower[14]. The present, open inquiry base science education (IBSE), didactical proposal also includes the educational use of comics (Kakalios, 2009), experiments with "low cost" materials, the use of smart-phone and/or tablet for wireless recording of students' responses, posters (Figure 5), interactive whiteboard (IWB), photo and video editing software (Figure 5) via a GoLab Inquiry Learning Space (ILS) (http://goo.gl/X4c4so). The educational objectives are from Bloom's revised taxonomy (Heer, 2012).

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[10] The present proposal took shape during the school year 2013-14 with the support of Sotiris Mandiliotis (Serres' LCS), Aik. Bezergiannidou (Consultant for Science Teachers), Konstantina Pilidou (Special Educational Consultant), Suzana Delic (Primary subject teacher & ICT teacher, Primary school Horvati, Zagreb, Croatia). This educational proposal will be (virtually) presented at the 3rd International Symposium On Creative Education - Creative School "Nook N Cornor", 16th - 19th November 2015, Finland
[11] http://golab.ea.gr/contest2015/content/contest-winners
[12] T.E.E. Ειδικής Αγωγής Α΄ βαθμίδας & Ειδικό ΕΠΑ.Λ. Σερρών, https://speduser.wordpress.com/
[13] http://ekfe.thesp.sch.gr/autosch/joomla15/images/ekfeArduino/freefall.pdf and here.
[14] http://en.wikipedia.org/wiki/Galileo's_Leaning_Tower_of_Pisa_experiment

ISBN 978-615-5511-06-6

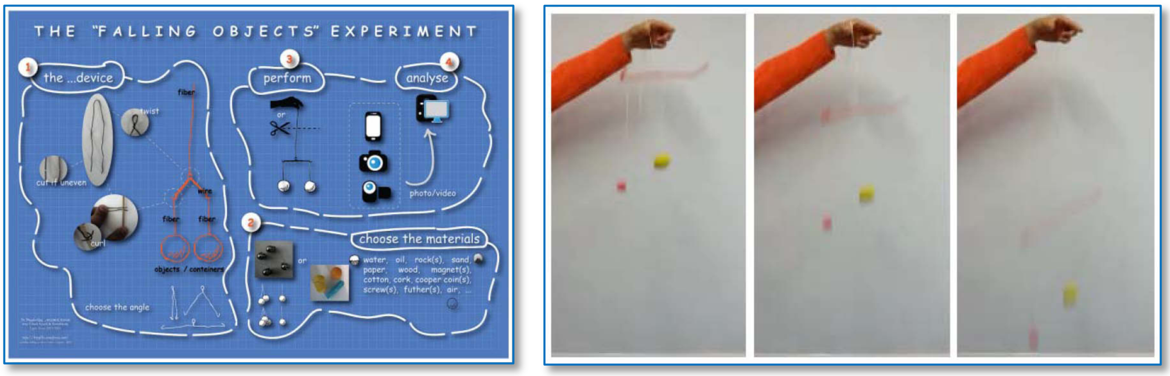

Figure 5. The falling objects experiment poster (left) and three snapshots of the experiment (right)

Environment & STEM Education (Νεράντζης, et al., 2015) – GreeNET project 2015

In the context of GreeNET a competition was launched via Facebook[15] on “How to shape environmental education for young people, so that their interest in the environment sector of the economy rises?” The first author took part with educational activities (http://wp.me/p3oRiZ-fo) with three (3) ILSs on Waste (http://goo.gl/IIm3z5), Wetlands (http://goo.gl/ZlBm4U) and Watershed (http://goo.gl/DCRbgz).

Figure 6. The post and photos from the “extend” phase

As “starting point” citizenship was set. We constructed a didactic proposal aimed at active learning, “framing” the concept of environment with the knowledge of European and Greek law[16]. We tend to provide teaching tools and good teaching practices (e.g. posters, video, GoLab/Graasp, metamnemonic questions, activities “outside the classroom”) based on STEM education, while integrating principles of inquiry learning and ICT. In the three ILSs “infiltrate” science subjects and environmental sciences subjects developing multiple connections and representations between them. Students are being involved with activities on material reuse, recovery, recycling and discussions (especially during the extend phase of inquiry approach on issues such as near space pollution, nuclear wastes, etc.) thus developing an environmental conscience. This research sets the “pillars” of a broader framework of individual integration through the development of critical thinking, both individually and in collaboration with others, aiming to raise awareness on human rights issues, sustainable

[15] https://www.facebook.com/GreeNETproject
[16] Directives 2008/99/EC & 2008/98/EC and Greek Law N.4042/2012

ISBN 978-615-5511-06-6

development, global peace and safeguard human dignity building, ultimately, a culture of peace[17].

Lasers & Bubbles (Nerantzis & Mandiliotis, 2015) – ISE project

The 2015 ISE Contest theme was on "Learning with light"[18]. "Lasers & Bubbles" was awarded as a top 5 finalist didactic proposal and the "title" of Inspiring Teachers for the first author. Moreover, the award was attendance of the Science on Stage (17-20 June 2015, London) Activities on exploring light's behaviour passing through different media (air, oil) was carried out two years ago (2012/13) in classroom. This year (2014/15) we repeated and enhanced these activities, visiting the Serres LCS, with the same five students with SEN who also carried out the experiments two years ago (Braud & Reiss, 2004). The didactical scenario has four (4) phases: pre-activities, main activity, post-activities and discussion – conclusion(s) – extend. The practice can be also found at UDLnet inventory (Riviou et al., 2015).

1st Phase: pre-activities (classroom – LCS)

Using IWB we recall our 2012/13's experiments on light. We listed the core scientific concepts (Staver, 2007) connecting with the Big Ideas of Science (GoLab, 2015). Staying on IWB we explored the "atom ≈ river" analogy (Figure 7). This analogy it turned to be a very joyful activity when the physics came alive and photons were the students and atoms where coloured papers on the ground (Kousoureta, 2015). With this dramatization, the students (holding hands and "trotting" on the papers) had to make decision on the materials separating line about where to turn: left or right? So, the physics of the rainbows can be implemented (Voulkoutzi, 2015). Educational objects on diffraction from the National Aggregator Photodentro (http://photodentro.edu.gr/lor/r/8521/1573) or/and PhET (https://phet.colorado.edu/en/simulation/bending-light) were included as well as the analogy with Takeshi's Castle (https://youtu.be/ScpJSlUmA9s). Visiting Serres LCS, we engaged our students to a plethora of introductory activities on lasers, total reflection, fibre optics, Morse code and bending light with sugar. We visited Serres LCS using local bus service and on foot. We wanted our students to walk, since as research shown (Chaddock et al., 2010) walking/exercise can help brain function (Schwartz, 2015; Henry, 2015). Moreover, many schools are orienting and adapt using stand-up tables in the classroom so the students «monitor themselves constantly throughout the day and make responsible choices about when and where they stand» (Guinane, 2015).

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[17] http://www3.unesco.org/iycp/uk/uk_sum_cp.htm & http://en.unesco.org/cultureofpeace/
[18] http://www.inspiring-science-education.net/competition

ISBN 978-615-5511-06-6

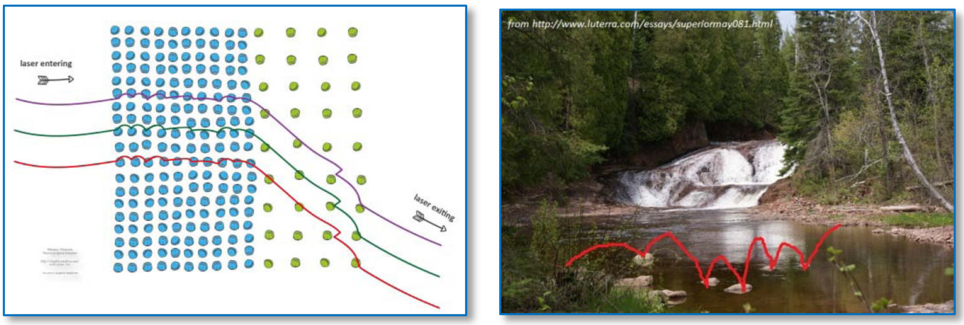

Figure 7. The atom ≈ river analogy (http://wp.me/p3oRiZ-hu)

2nd Phase: main activity (LCS)

After the introductory activities we gave the students directions about their main activity and we let them experiment & play first: If students experiment first then they can understand theory better (Plotnikoff, 2013). The objective was to explore, describe, inquiry and explain light’s behaviour (microscopic approach) passing through different media – under teachers’ very discrete guidance. We have to point out that all the hands-on activities of the main phase were hands-off activities for us (the teachers) since «*hands-off teaching cultivates metacognition*» (Maats & O’Brien, 2015). Moreover, in order to promote self-reflection and regulation prior every task, I was asking my students if the task was seemed difficult (or not) and why. After the task I was asking the same question again. The objective was, through strategies of metamemory, to monitor the learning procedure through Ease of Learning (*EOL*) and Judgment of Learning (*JOL*) questions (Karably & Zabrucky, 2009).

3rd Phase: post-activities (LCS – “Heraclitus” science museum)

At the end, we engage students into some very interesting activities: & videos, eye-doctor trick, red-cyan 3D vision (https://youtu.be/X7RF7NvSu6A) so to raise the mechanism of human site. Finally, we visited the “Heraclitus” science museum (in the same building with LCS) (http://1gym-serron.ser.sch.gr/index.php/mouseio-irakleitos/ekthemata-mouseiou-hrakleitos) and we saw and interacted with didactical experimental apparatus nearly 100 years old (Figure 8). This was a very in triggering experience since we connected not only with science history but with our educational history.

4th Phase: discussion, conclusions, extend (classroom)

At the classroom each student presents his conclusions and we discussed about the final results and outcomes of our project. We summary of the project, we revised and extend, connecting with everyday life through a plethora of the Inspiring Science Education (ISE) resources[19]. The Extend sub-phase is a very important phase for deep scientific understanding of core ideas and the development of everyday life skills.

[19] e.g the Energy Poster (http://portal.opendiscoveryspace.eu/node/822367), GoLab’s remote lab The color of the light (http://www.golabz.eu/spaces/color-light), Newton’s mistake (http://portal.discoverthecosmos.eu/node/132277), Eye resource (http://www.inspiring-science-education.net/sites/default/files/1_14_Eye.pdf) and “Eyes' hidden secrets” (http://portal.opendiscoveryspace.eu/el/edu-object/eyes-hidden-secrets-675434), Aurora Borealis

ISBN 978-615-5511-06-6

Figure 8. The three (3) "blue" posters for Lasers & Bubbles (up), the reflector apparatus and (lower left), the colladon apparatus from "Heraclitus" Museum and (lower centre) the eye doctor trick (lower right)

Universal Design for Learning (UDL) principles application[20]

Grounded on new research in neuroscience and the Design for All principles, Universal Design for Learning (UDL) constitutes an educational approach that promotes access, participation and progress in the general curriculum for all learners (CAST, 2015).The difficulty is in all cases translating the UDL principles and guidelines into practice. In order to bridge this gap between policies and practice the UDLnet network aspires to address this necessity collecting and creating good practices to the dedicated repository designed and developed for this purpose. Education stakeholders are invited to record their Good Practices (http://udlnet.di.uoa.gr/). The educational activities described being implemented in mainstream and SEN education have been described under the prism of the UDL principles in order to help the various stakeholders understand the potential of UDL. Figure 9 depicts the way and degree that the above mentioned educational activities apply the UDL Principles on the UDLnet Repository[21].

Conclusion

The educational activities presented involve students working in teams and as researchers; testing, adjusting, inquiring and exploring different aspects of a problem. The educational outcomes are among others knowledge gaining on the core scientific ideas, better relationships between teachers and students, and boost of students' self-esteem. The emotion component has been integrated in learning (Hinton, et al., 2008), long term teachers' cooperation and consistency and continuity to teaching. The first pillar is to offer students

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(http://portal.opendiscoveryspace.eu/edu-object/aurora-borealis-13547) & Aurora Australis and their colours (https://youtu.be/hC7QroiDVQw), http://portal.discoverthecosmos.eu/node/107194

[20] UDL is not completely new for education stakeholders and in many cases can be partially applied unconsciously.

[21] http://udlnet.di.uoa.gr/index.php/best-practices/browse-best-practices at the Main Topic (menu on the left) click Science (you must register)

ISBN 978-615-5511-06-6

educational activities in order to facilitate their learning and to provide them the necessary experiences for life. The second pillar has been the design of innovative educational activities a process that has been facilitated with the participation in networks, such as ODS and UDLnet, online communities of practice, the participation in teachers' contests, face to face trainings such as workshops and summer schools and teachers' exchange of resources, practices and experience. All the above are objectives to an effort for an inclusive education and they were developed with use of open access scholarships and open educational resources" (UN, 2014).

UDL Principle I: Information/Instruction offered in different ways

1st Guideline: Relevant information is available on the learning objectives and outcomes
- in advance
- at any time
- temporarily
- on demand

How this guideline was implemented: visual aids, posters, artifacts

2nd Guideline: Information can be assimilated in various ways
- visual

3rd Guideline: The understanding/comprehending of information is supported by providing various options
- illustrations
- gamification
- practical demonstration

How this guideline was implemented: students have the opportunity to experiment

UDL Principle II: Allow the learners to express what they know in different ways

4th Guideline: Learner can actively work with the learning materials in different ways
- individual work
- group work

How this guideline was implemented: students can work indivindually or in small groups

5th Guideline: Learners can show the results of work as ...
- textual description
- individual oral report
- group presentation

How this guideline was implemented: students have the flexibility to demonstrate the outcomes of the learning process in a variety of ways

6th Guideline: There are different forms of support provided such as ...
- face-to-face mentoring
- online mentoring
- feedback on demand

How this guideline was implemented: the role of the teacher is centred around students' needs

UDL Principle III: Learners are engaged and motivated in different ways

7th Guideline: Different known interests and motivators are addressed such as ...
- authentic tasks
- choice in context

How this guideline was implemented:
the active involvement of students makes them motivated

8th Guideline: Interests and goal attainment as well as resilience are stimulated actively by ...
- practical relevance

How this guideline was implemented: students have the opportunity to run hands on experiments themselves using low cost materials

9th Guideline: There are opportunities for self-regulation provided...
- creative freedom
- beneficial learning environment
- independent diagnosis and assessment of the finished learning process

How this guideline was implemented: students metacognition is supported with the use of specific questions (self-reflection, learn through trial & error) this is supported with use of the inquiry method (IBSE), pre-activities, activities in the lab (with use of real artifacts), experimentation, post-activities (support of metacognition, transfer of knowledge)

Figure 9. Screenshot from Lasers & Bubbles activities described following UDL Principles on UDLnet Repository (http://udlnet.di.uoa.gr/)

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Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

TABLETS AND SPECIAL EDUCATION – A CASE STUDY IN GREECE EARLY RESULTS OF THE 1ST YEAR

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Abstract

This paper follows up the early results of a the research that is taking place at the School unit of Special Gymnasium and Special Lyceum of Athens and had started almost 2 years ago. The rapid technological advances the last few years have lead to significant changes in the field of education. The use of mobile devices, iPads and other tablets put technology in student's life in a different way than it was before. Hand-held devices offer to students with and without disabilities easy access to learning opportunities, information, organizational systems, communication, and, interestingly, emotional support (Newton & Dell, 2011). According to McMahon and Walker (2014) not only students, but the educators at all levels, are adopting mobile devices and are finding exciting ways to use them in their instruction. IPads and tablets succeeded to be part of their life in such a short time because they are portable, intuitive to use, and they provide a different modality of learning, one that has an element of fun. A great number of researches are running around the world about the creative involvement of these devices in the educational procedure. Taking under consideration the positive impact of tablets and iPads in general education, researches are exploring the impact to special education. Possibilities in terms of learning, self-expression and (digital) inclusion are exploring in these researches. People with special educational needs (SEN) are not afraid of using new technologies especially tablets and iPads, what is crucial for them, is that they are given the chance to use them and get the support they need. As a result, a great number of applications for SEN have been built for android devices and iPads such as Proloquo, Peeping Musicians from Inclusive Technology, BBC Something Special, Magic Finger from Inclusive Technology, Load2learn, Grid 2 and many more. In this paper, is going to be presented the first early results of a case study from the use of tablets in a Special School Unit in Greece. It has two parts on concerns students with severe physical disabilities who are facing serious problems of communications in their daily life and the other concerns students with severe physical disabilities who are facing less serious problems of communications in their daily life but they are facing with cooperation problems. Inclusion is their classroom and collaboration with their classmates are studied. The results are positive and seem to confirm the research results from using tablets in classroom. There are a lot of things that have to be taking in account, a serious parameter, is the Greek laws for education that are putting a number of limitations in the use of hand-held devices in classroom.

Key words: Tablets, Applications for SEN, SEN students, Cooperative Learning.

Introduction

In the last few years a lot of things have changed in the field of the education. Technology has given a lot of aspects to the didactic of sciences that were not so attractive for the most of the students and has provided ways out for students who face limits to their education because of various factors (environmental, physical, economical etc). Researchers and educators support that using different classroom technology like tablet PCs, digital video, iPods, and video games help students to learn. According to Johnson (2013a) as tablet Pc is defined "a single panel computer with a touch screen as input device. More specific, a tablet, is a mobile computer with display, circuitry and battery in a single unit, it combines the capabilities of the traditional laptop with the added features of pen-based digital linking for handwritten notes and symbols, resulting in a very versatile tool (Steinweg, Williams & Stapleton 2010). Tablets are equipped with sensors, cameras, microphone, accelerometer and touch screen, with finger or stylus gestures substituting for the use of computer mouse and keyboard. Tablets usually feature on-screen, pop-up virtual keyboards for typing. Tablet computers are in these days a 'must have' consumer item. IPad was the best-selling tablet in 2014, followed by products from Samsung, Google, HP, LG, Asus, Microsoft, Sony and others. Tablets' sales are expected to overtake PCs in 2015, in such a way that some manufacturers are thinking ending production of laptops.

Tablets are used in schools in ever-increasing numbers, as prices come down in a competitive market, and with the added attraction of a big number of free or low-cost educational apps, and the arrival of tablets specially designed for schools (e.g. the LearnPad). A great number of pilot programs for developing educational applications and platforms for hand-held devices such as Demibooks School pilot program, You Can Tech It, etc are running. There are many examples of 1:1 classrooms where every student has a laptop or a tablet (researches estimation was around 47000 schools in Europe for 2013 (Balanskat, Bannister et al., 2013). In some countries tablets are provided to students either by the school or otherwise under some state programs such as 'Bring Your Own Device' arrangements (Spain, Norway, Sweden) (European Schoolnet for the European Commission, 2013). In the last couple of years there have been projects and researches evaluating their use in educational procedure (Creative Classrooms Lab). In Greece, legacy educational system is a little complicated and their use is still held back. A number of issues have to been solved before tablets can official be included to the curriculum. Although students and especially students with disabilities are really attracted to hand-held devices and they prefer them from desktop computers and even from laptops and notebooks, enjoying their benefits of a different modality of learning, which has an element of fun, there are a number of obstacles preventing them from being part of school daily life and activities.

In the same time, the trends in education and technology for the coming years are tablets in schools, cloud computing, social media, online learning, games, non-formal earning, and mobile learning (New Media Consortium, 2014). Their design, their ability to browse internet and to access a very big number of applications, to view and/or to "create" documents, presentations and videos anywhere and anytime make them ideal tools and give to the school leaders designers reason to put tablets at the centre of teaching and learning. A number of issues should be considered if tablets are to be at the centre of teaching and learning. A big importance issue, is that, they should be usable and effective at least for the fifteen per cent (15%) of students with special educational needs (SEN) in schools, and, crucially, the educators need to be aware of the accessibility features built into the operating systems of tablets and of the range of apps for students with special needs. Furthermore educators therapists and all the specialists who are involved with Special Education should be trained to access and use the right application for each student (depending on his individual needs) and in the same time to keep the educational process ongoing.

Theoretical Framework

Tablets and special needs

Although tablets were not designed to be educational tools, they quickly moved into schools (Grezlak, 2011; Jackson, 2011; McCrea, 2010). Educators at all levels of education are adopting mobile devices and include them in their teaching methods, finding exciting ways to involve them in their instruction (McMahon & Walker, 2014). According to Newton and Dell (2011) these hand-held devices offer students (with and without disabilities) easy access to learning opportunities, information, organizational systems, communication, and interestingly, emotional support. Researchers support that tablets features that appeal to the general user (simple interface, portability, speed, affordability, built-in camera, internet connection, location services, variety of apps) are the same that make them a valuable tool that can enhance teaching and learning (Schaffhauser, 2013).

There are a number of their features that make tablet to be outclassed than to other devices. SEN students can access it much more effectively than a PC using its touch screen. Applications like Avaz, iStudiez, Kurzweil 3000, Stories About Me, iCommunicate, Tibio, MyCo-pilot, etc support children and adults with special needs and gave them abilities to accomplish many things in the classroom that were difficult or even impossible for them only a few years ago (Amstrong, 2013; Mitra & May, 2013). Touch screen offers immediate feedback, as what is seen and heard emanate from where the fingers are on the device. This immediate feedback helps to keep students engaged who may get bored/ frustrated easily with delayed feedback. Touch screen offers a variety of sensory input and experiences. The most successful teaching with children with special education needs involves visual, auditory and kinaesthetic (tactile) learning. According to Professor Mary Cronin, kinaesthetic piece which was missing from learning software and from many classrooms covered partly satisfactorily with tablets' hands-on element that is easy to use. And as Dwight (2013) supports even though it is not as sensory as true tactile learning, it still uses that part of the brain. They increase the possibilities for highly individualized use which is a further advantage, via the personal selection and organization of applications (Johnson, 2013b). Another advantage is that they support the move to cloud-based and web-based software, which according to Ian Swain (In Technology & Design professor at Bournemouth University) is identified as the biggest push in assistive technologies at the moment. Till a few years ago the earlier education software

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which was being installed on one single computer, the SEN student was usually stuck on a single computer. New technology gives opportunities to a SEN student to switch easier between different devices, according to his needs and activities (Schaffhauser, 2013). Researchers agree that tablets help differentiate between different styles of learning and learning abilities and give alternative ways of accessing and presenting knowledge to those students that struggle with traditional ways in the time when specialists claim that when people allowed to develop according to their natural rhythms, and learn in their own unique way, it become possible for them to achieve a sense of meaning in their lives, and enables them to share their remarkable gifts with the broader culture, thus making the world a better place in which to live(American Institute for Learning and Human Development 2015). Johnson (2014) recognizes significant benefits of tablets for SEN students, they motivate to learn and enable more personalized learning, as it is easier to individualize instruction and to track progress and to erase/ change/ customize content to suit individual students' needs (Robinson, June 2014).

But tablets support collaborative learning as well. In the time which collaborative learning is demanded and the inclusion is imperative, a further appealing aspect of tablets for students with special needs is their inclusivity. They provide SEN students with chances to come closer to their classmates. Tablets are opening up a new world of possibilities for SEN students (SENnet 2014-UK report, 2013). Researchers support that "with the right applications, SEN students were able to keep up with other students in the class and do assignments using the same device as their peers, in addition to receiving immediate feedback" (Tablets for schools, 2014c). Additionally, using tablets enables SEN students to gain a sense of achievement in learning the same material as other students in the class (Tablets for schools, 2014c). Finding of the same research was that SEN students gain a sense of achievement when they use the same apps as other students (Tablets for schools, 2014c). The use of the same device from all the students is crucial because for students with special needs the use of same device as the other students does not set them apart (Clarke, Svanaes & Zimmermann, 2013). An example, is given by Hanan Elattar, a music teacher in the United Arab Emirates, who created an orchestra and included students with special needs by replacing instruments with iPads. In the orchestra were included students with Down's syndrome, autism and physical disabilities (Nazzal, June 2014). In the USA special educators and therapists use iPads to help students (many of whom have cognitive impairment and developmental disabilities) with a host of issues, including communication, reading, fine motor skills, writing, and handwriting. The iPads have appeal to students SEN and special educator and therapists for a number of reasons. Firstly, the learning applications (apps) are usually engaging and perceived by students as fun. Furthermore, they have a strong learning component, and they can be used as a reward for a student who has worked hard. In addition, with new apps being developed daily, educators can find apps to supplement just about any lesson they are working on (Fischburg in Dwight, 2013). Researcher claim that tablets can also serve as a bridge between students with and without disabilities.

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A number of researches are "running" for the benefits tablets have on special education. There are some early research results on the benefits for SEN students in general (Clarke, Svanaes & Zimmermann, 2013; Johnson, 2013a) that chimed with the results for particular SEN groups like autistic children (O'Mally/ Lewis, 2013) and the visually impaired (Cranmer, 2014) which suggest that tablets are increasingly perceived as essential in special education classrooms (Dunn, 2012). A small-scale USA study carried out by the Kennedy Krieger Institute with autistic children found that "iPads can be an effective instructional tool to enhance learning and independence" (O'Mally & Lewis, 2013). These findings are supported by the survey carried out by the Curtin University in Australia and as Johnson (2013a) mentioned surveyed teachers and teacher assistants were extremely positive about the value of the iPads for SEN students, particularly for students with autism, attention deficits and limitations of fine motor control.

Tablets as assistive technology

Hand-held devices were not the first devices used in special education classrooms. Special educators have used a variety of software for years to teach and supplement lessons in math, reading, writing, organization, and memory. Other assistive technology devices help students with listening, sitting, using the desktop pc, communicate and carry through with the school daily life. The devices which have opened up the world of technology to the average classroom and have been instrumental in helping some of the most challenged students read, talk, and connect, were iPads and tablets. Unlike some specialized assistive technologies, tablets have the capacity to include a comprehensive array of activities (Johnson, 2013a), furthermore they concentrate on the individual needs of person may have (Niemann, 2014). Dunn (2012) claims that their accessibility features such as VoiceOver, Zoom and Large Font, White on Black Display, Closed Captioning and Mono Audio or Voice Control enables with instant access, rather than having to wait for the device to load the appropriate software. And by the use of these features, tablets can provide a person with a 'voice', enable blind learners to access texts and provide speech or symbol support to reading and writing where text is a barrier (GoLearning, August 2013). Researchers indicate that tablets can replace specific assistive technologies in some cases. Schaffhauser (2013) claims that students with autism or speech disorder can use tablets with voice output or communication board app instead of a traditionally used communication board. Additional SEN students do not stand out as using something different any more since the tablets are indistinguishable from devices used by other students (Robinson, June 2014).

Children who have communication problems can get frustrated at school and may also have problems making social connections. With an AAC program for the iPad, or tablets, student can find his/her voice. These apps (Proloquo2Go for iPads or Innoetics TTS Reader, Voice4u3, Avaz4 and Avaz FreeSpeech5 for tablets) are highly individualized, so student can have a separate set of words programmed for when he/she is in class, at break, or on the gym and with the press of a button can say anything instead of acting out to get that message across (Dwight, 2013). A study held in Toronto in 2013 showed that using communication apps increased augmented and verbal communication, and self-initiated interaction with peers.

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Another study looking at math skills for second-graders with learning disabilities using hand-held computer-assisted instruction, found that students improved their subtraction scores by an average 17 percent.

As it has already mentioned, tablets have the potential to become a powerful inclusive device. Another advantage is that using tablets and free applications is much less expensive than assistive technologies. Therefore, they are also easier and quicker to replace in case of loss. According to Samuel Sennott, the fact of SEN students starting to use tablets has been put pressure on developers to produce more attractive AAC systems (Dixon, October 2011). Mainstream devices like tablets put pressure on the market for assistive technologies. Until 2011, the average price for AAC systems in the US has fallen from $7,000 to $700. The price drop presents an innovators' dilemma for the incumbent AAC-focused companies, but it is a huge opportunity for the field to serve a greater number of people (Dixon, October 2011).

SEN students with physical disabilities/kinetical disabilities

There are benefits from the use of the tables and more generally from all the hand-held devices for all the categories of SEN students. Students with autism are provided from tablets with instant feedback, which is particularly important for them, they are helped to communicate, to learn socialization skills and to structure their daily environments (the Forecaster, December 2012, Tablets for schools, 2014d). Students with attention deficit hyperactivity disorder (ADHD) can be benefit from tablets and their applications. Mind mapping and visual based organization tools (e.g. visual timetables), are using for students with ADHD. Simple Mind TM, Mindmeister and "Focus GPS"6 are applications for users with ADHD. For students with visual impairment, the setting options of tablets to change font, size and background colours can be very helpful. Additionally applications like VoiceOver7, Talkback and Brailletouch8 enable hand-held devices as a necessity for people with visual impairment. Having a variety of input and output methods, tablet provides easy access to a variety of users. For students with motor skills impairments, the touch screen is easier to use because they do not need to control their finger as precisely as with keyboards or other writing utensils. Tablets are also used to contribute to the development of these skills (Johnson, 2013a; The Forecaster, December 2012).

Case Study

This study is part of a research that is taking place at the School unit of Special Gymnasium and Special Lyceum of Athens. It aims to explore how new devices can be used during learning procedures from students with severe disabilities, in second time to develop and study teaching scenarios, in order to improve the quality of the learning procedure for the specific category of students and to find methods that will ensure the equal participation of all students during the learning procedure, both in the strict limits of a classroom and the wider borders of each educational activity. Since cooperative learning, supported by ICT, is suggested for students with special needs (Schulte, 1999; Cohen et al., 1994) and especially for those with physical disabilities (Petrou & Dimitracopoulou, 2014), it aspires to study cooperative educational activities using technological tools and assistive technology and their

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effect on the participation of students, on the quality of cooperation, and to examine the sociograms of the students in the classroom and finally the cognitive results. The students of this school unit are facing physical disabilities which in many cases are accompanied with visual impairment, learning difficulties, ADHD, autism, hearing problems. Students with physical and multiple disabilities compose a complex and heterogeneous population.

Research procedure

Research goals, questions and methodology

In this small scale study it is applied a non categorical approach, which means that children with various disabilities and, subsequently, with various specialities and needs are going to be studied in common (Rowitz, 1988). At the first part of the case study the only common characteristic of the students is that cannot independent participate in the learning procedure using the common and existing assistive technology. The four (4) of them are incapable of common communication because of they are having serious speech impediments. The central axis of the teaching procedure was to make students act independent communicate with the educator, the therapist and the classmates and to work together in order to produce a final teamwork result and promote principles of a social character. In the second part of the case study the common characteristic of the students is that they are all members of the same class, they are almost at the same educational level and they cannot cooperate well during the educational procedure. The teacher/ researcher during some phases of the activity kept the role of the observer. In some other cases had a more active role either as organizer of the general activity or as coordinator of those conversations/activities which were organized by scenario, together with the planning of the activity, elements concerning each student were collected and classified in order to create the personal report of every student including data for their personal relationships and their sociograms.

The central search question under inquiry is summarized as followed: Can the tablets used in a class in order i) to involve all SEN students in the learning activities even them with serious speech impediment or serious communication problems, ii) to achieve cooperative learning iii) to motivate/activate students with different kinetic disorders and different LD, iv) to achieve interaction, v) to improve quality of lesson? Do they stir them up in order to work as a group, and at the same time help each student achieves specific learning goals?

Description of the group – Characteristics of the population

The study started at the spring of 2014. The children selected were three (3) students of 2nd grade of Junior Special High-school and it is proceeding from the autumn of the same year with the participation of two (3) more students, one of the 1st grade of gymnasium and two from the 1st grade of Special Lyceum. The first three students, who are now, attending the 3rd grade of Junior Special High-school, are having serious difficulties in using the assistive technology that was installed in school desktops (sensors for eye-tracking, trackballs switches etc), that is one of the reasons that were chosen to participate in this case study. They are all males and sited in wheelchair. Their ages are 14-16. Two (2) of them, John and Tom are in the same class, they are having cerebral palsy and they couldn't communicate with their

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classmates because they have speech impediment that makes them very difficult to be understood. John condition is a little bit harder since he is having spastic quadriplegic cerebral palsy, had also problems making social connection and was aggressive with those who couldn't understand him, he was also bilingual. The other student from the other class, Endy is having muscular disorder and his physical condition is very bad, and getting rapidly worse, he cannot move his arms nor his legs, he can use his hand figures and his head, although he is bilingual he doesn't face any learning difficulty. He is having also a visual problem. His situation doesn't allow his to use neither eye-tracking nor trackballs and special switches but it was noticed that he was using well enough a Smartphone so he was given a tablet to work with in school. The two of the three new students are females. All of them are having serious speech impediments that make them almost impossible to be understood. They are also sited to wheelchair and they can communicate only by the use AAC. Miriam, the one of the first grade of gymnasium is very intelligent. She is 12 years old and she doesn't have learning difficulties. Sandy on the other hand is 17 years old, she is having serious spastic quadriplegic cerebral palsy, she can use only her head and she is also bilingual. Till few years ago she could use with the help of switches for the head only her pc which had specific software and which had given to her limited chances to communicate and moreover to participate and cooperate in the learning procedure. Jacob is also 17 years old he also having spastic quadriplegic cerebral palsy his facing some learning difficulties because of this inability to efficient communication. The names that are used above for the participant students are pseudonyms.

In parallel with the observation of the progress of these four students, another class was observed in order to study (b), (c), (d) and (e) sub questions of the basic question of the study. More specifically Tablets were used for the lesson of Informatics by a selected class of 2nd grade of Junior Special High-School in the spring of 2015. In this class there are 8 students, 4 males and 4 females, they are not facing serious learning difficulties and only two of them are using assistive technology (trackball). They are very good students and they are very interesting in new technology. Two of them are bilingual, and two are sited to wheelchair. Three of them 2 girls and one boy are facing speech problems (but they can be understood by their classmates and their teachers). Their ages are 14-16. This team doesn't cooperate well and efficiently. There is strong competition between the students of this class especially between the males.

Tobii tablet – a brief description

The school unit owns two Tobii tablets of c series and more specific c12. They are having camera, microphone, speakers, EDU(Environmental Control Unit) Bluetooth, Mobile phone, WLan. Like all tablets touch screen, adjusting the backlight, the sound, are the basic features that are used for the learning procedure. Grid 2.0, Tobii PCeye, Tobii communicator 4, Sono Key and TTS Reader are applications installed in the tablet ready to be used from the students. The Tobii CEye Module is an eye control unit which is designed to dock seamlessly into a Tobii C12 or C15 (not used with C8) and operate with precision regardless of glasses, contact lenses, eye colour or light conditions. The CEye Module enables SEN student to control the computer with eyes. By looking at the screen, user controls the mouse pointer and clicks by

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blinking, dwelling (staring at the screen for a certain length of time) or using a Switch (C-Series User's Manual).

Description and Application of the Activity – Early Findings

First Part of Study: The 4 selected students were drilled to use effectively the tablets and the provided applications so they can overcome the obstacles placed by their situation. Each one of them was trained according to his individual needs so he can communicate, interact and participate to learning procedure. At first John and Tom were using the devices and the AAC app to gain a voice, and to cooperate with their classmates and their educators and therapists. They were trained to use Grid 2.0 so they can access in a short time their personalize submenu depending on each time demands and needs. Secondly to participate to learning procedure in more equal terms. For example apps like Socrative were used to evaluate their knowledge in Informatics Test at the two tests in the semester and to the final exams. In that way students access by themselves the app though internet (though tablet or desktop) answer and had immediate feedback. It seems to improve themselves using this way of examinations since they achieved better scores than their "oral" exams. Using TTS Reader combined with Grid 2.0 they could participate to informatics assessments which were planned to fit to the set of the class. For example in one last year's completed assessment, students had to develop a project about technology, communications and their involvement in astronomy, using at least 6 different resources. After completing their assessment they had to present their final project to their classmates. All of the students at the end had to vote for the best assessment using Socrative. At first with a lot of difficulties but much more easier while training was going on they were able to prepare and to create a composition for the common subject that they were asked to analyze. During the process they have the chance to interact, while using general guidelines provided for each phase. The whole process was being done under the supervision of the teacher. They seem to enjoy the entire procedure, especially as they started to be understood by the teacher and their classmates and to achieve their goals. John felt better and his aggressive attitude was downsized. Endy, the third student of the first year case study used PCEye to control tablet and to overcome his incapability of controlling alone the desktop and be independent during the learning procedure. The two girls and the boy who joined the study this autumn use the tablet in school for all the above reasons (to gain voice, to interact, to communicate, to express themselves, to cooperate and to participate to the learning procedure. The first signs are positive, of course it is too early to come to conclusions but in these 4 months the most of the signs are fostering the students and teacher's and therapist's try. It has been noticed that they have more willing to attend the lesson of Informatics and they are impatient to express themselves and to participate to the learning procedure and to achieve an assignment. Researcher /educator keep notes and calendar with all the events and data of the learning procedure. Students progress was evaluated according i) to their progress relatively to their limitations there are facing because their physical condition ii) to the participation in the learning process, iii) their attempt to create relations with their classmates and iv) according to the cognitive result.

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Second part of the study: The students of the selected class were allowed to bring their own hand-held devices to the class. Only one of the 8 students didn't own a tablet and the educator provided him one. Prezi, Socrative, Pixlr, and Scratch were the software and Edmodo was the selected platform that was used from the educator and the students the period of the case study. Interactive whiteboard was also used, mainly from the educator. Multimedia, Image Possessing, Presentation creation and Programming were the fields of the Informatics that were taught to this class from February till May 2015. Students have the chance to interact during the process, while using specific guidelines provided for each phase from the scenario of each thematic area. Students worked alternative in groups of two or in groups of four to search and to understand a topic that was given each time depending on the thematic area, find solutions to a given problem or create a product together. Only in the last two projects of the last two thematic areas (Programming and the Multimedia) the 2 teams were the same (males in the one team and the females in the other team). The whole process was being done under the supervision of the teacher. As it has already referred above the researcher /educator keep notes and calendar with all the events and data of the learning procedure. Students progress was evaluated according i) to their progress relatively to their limitations there are facing because their physical condition ii) to the participation in the learning process, iii) their attempt to create relations with their classmates and iv) according to the cognitive result.

Results

Regarding to SEN report(2014), some of the tablets benefits are motivation of the SEN student, personalisation, they make easier to individualize instruction, track progress and to erase, change customize content they provide alternative ways of accessing / presenting knowledge and it can be differentiate between styles of learning/ learning abilities(Engelhard, Blamire 2014). Tablets engage the 4 the Four Key Components to Learning so benefits are also for the same the education procedure and for educators that use tablets. For example they have the chance for professional development as well as better organize their tasks (tasks inside and outside of teaching Tasks outside teaching are: including planning lessons, grading, meeting with parents, and some administrative work).The use of Grid 2.0 was no very easy although the existence of manual, the trainers and the educator involved in the study noticed that they had to be trained from the state using such a tool, either by seminars or webinars. Researches have shown that all these jobs can be better organized with the help of these easily hand-held devices.

The first early findings of our study come to validate the existing findings in both parts of the research. More specific, for the first part of the study: Firstly the three male students have been affected positively from the use of the tablets in the educational procedure, one the one hand they enjoy using tablets and their apps, on the other hand significant improvement was observed in relation to the communication and educational level of students. For first time students with serious and severe problems including serious speech impediment, could participate to the learning procedure in equal terms and to be evaluated in the same way as their classmates. The first results of the girls involvement in the study are enhanced the previous findings and stand for the use of tablets in education procedure. As it is already

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mentioned these early results are positive and they enhance the results of other researches for the use of tablets by SEN students in the learning procedure. Benefits are for teachers also, they can reorganize their lessons making more attractive, more enjoyable, more interactive. They can "invite" specialists to their lessons through conferences or webinars and to provide their students with the best data removing the limitations and obstacles. There are not only benefits but there are also difficulties that SEN students face during their training. They have to exercise in the use of these devices and their apps, especially the PCEye app because of its necessity of accuracy and calibration et. Of course there are not only students who have difficulties with these apps but teachers too who either don't have time to learn how to use it, or they don't have time to plan, create and use new learning processes because of the Greek 's educational system demands and limitations. Many more parameters have to be studied to ensure the validity of the findings and to explore more efficient involvement of the SEN students in the learning process to achieve cooperative learning by using all the available and suitable products of technology, always in the spirit of the of enrolment and embodiment.

Second part of the study: The limited data that derived from the narrow time period of the study validate the existing foundings about the hand-held devices and cooperation. The 8 students at the end of the school year managed to cooperate in their class in order to achieve an educational goal. Competition started to ebb by the time students worked together for the creation of their team projects under specific instructions. Of course it has not been eliminated yet. Misunderstandings especially in the programming field was early detected with the help of the online quizzes of the educator and hers immediate access to the students' results. Socrative and Edmodo helped educator/researcher to evaluate students' effort as individuals and as well as member of a team. Students evaluated the software they had used, the scenarios, the Edmodo platform and the educator during the teaching of these 4 thematic areas by online evaluation forms that were created in Socrative. From all of the used software, students disliked Prezi. They couldn't work easily to Prezi's environment and the faced problems with the loading of their project. They liked the use of the tablets in the education procedure and the sense of freedom they had thanks to these devices and the online applications they used. In this part the students were not evaluated according to their progress relatively to their limitations there are facing because their physical condition (speech difficulties) but only to their learning difficulties. In conclusion the first results are encouraging; tablets are a strong tool in education field and more specific in SEN. They support collaborative ways of learning(such as peer learning, mobile group-work, and project work), but there are still a lot to be studied such as students relationships with the help of SNA, students progress, more applications for hand-held devises for educational purpose and SEN applications for hand-held devises in order to achieve the best proposal for each SEN student.

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

TEACHING PE THROUGH MATHEMATICS, PHYSICS & WEB 2.0 TOOLS IN SECONDARY EDUCATION: IMPACT & CHALLENGES

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Background and Introduction

As a teacher of Physical Education (PE) experimenting occasionally with new teaching methods within the boundaries of the school curriculum I have an interest in inspiring students to adopt a healthier way of life. Subjects such as Mathematics, Physics, Chemistry, Biology and Information and Communications Technology (ICT) can be used to achieve that goal. The Open Discovery Space (ODS) contest "The Science of Olympic Sports", urged PE teachers to design an innovative educational scenario using ICT and interdisciplinary material. ODS contest gave us the chance to present an innovative educational scenario and to interact with other colleagues with whom we share the same desire to make PE an interesting and modern subject. We exchanged ideas, teaching methods and planned future interschool cooperation.

The main idea of the present educational scenario was to prompt students to participate actively, especially those who aren't very skilful, in sport activities and to understand the relationship of physical education to other cognitive fields. The Olympic event of Shot Put was chosen because it combines features from various fields, such as Mathematics, Physics, Biology, History and more. By understanding this relationship, the students will feel more capable or at least they will try to participate more actively in PE, a subject often misunderstood in the higher grades of Secondary Education. ICT played a very important role by bridging these cognitive fields. The present educational scenario included collaborative activities, learning by doing, field research, simulation, 3D modelling, collaborative Web 2.0 tools (Wikis, etc.). The results from the implementation of this innovative educational project were a clear change of attitude towards PE both in school and in life. Furthermore, through the use of interdisciplinary material the students were able to understand the relationship and the possible interaction between these cognitive fields, while they realized in practice the meaning of "a healthy mind in a healthy body".

Challenges

The greatest challenge in this particular educational project is to inspire the students to have a positive feeling towards PE. The use of ICT and other cognitive fields towards this goal is somehow confusing. The different nature of the various fields such as Biology, Anatomy and Physics make this project even more difficult. Nevertheless, when the students understand the relationship and the possible interaction between two seemingly totally different cognitive fields (PE and Physics, for example), then both subjects have gained an enthusiastic student.

Although teachers have good intentions when they plan interdisciplinary courses, these courses frequently lack sustainability. Two problems in content selection often plague courses: These are the “Potpourri” and the Polarity problems. In order to address these problems, teachers must carefully conceive design features (a scope and sequence, a cognitive taxonomy to encourage thinking skills, behavioural indicators of attitudinal change, and a solid evaluation scheme); and they must use both field-based and interdisciplinary experiences for students in the curriculum.

Educational project methodology

The educational scenario has three phases and each phase has subsections with activities. The first phase consisted of specific stimulus, brainstorming and organizing the structure of the project. The second phase is the main phase where the relationship and the interaction between PE and the other cognitive fields are investigated. During the third phase results and conclusions from the project are presented to the school community.

During the first phase a specific stimulus is used to trigger a brainstorming where the students discuss regarding the problem and suggest a list of ideas for the structure of the project.

- Activity 1: In this activity an awarded short film named “3X3” is presented to the students. The story which involved basketball, mathematics, physics and anatomy is an excellent way to get the student’s attention. After they see the film they are called to discuss about the story and what is the main idea. Through questions and answers we start to focus on the throwing technique which is common in many sport events, such as Shot Put. At the end, a team worksheet is given to the students to gather information with the use of the ICT regarding the throwing event of Shot Put.
- Activity 2: in this activity the students with the help of two teachers (PE and CS), create a Wiki in order to put all the information in digital form. This way all the information, worksheets, papers and relative digital content are accessed by everyone in the team. Brainstorming and Jigsaw (cooperative learning strategy) are two methods used in this activity.

The second phase is the main one. Learning by doing, field research and interdisciplinary lessons are the methods used in this phase. The use of Web 2.0 tools is also very frequent. The main goal is to examine the relationship between PE and the other cognitive fields and their possible interaction.

- Activity 1: the PE teacher and the students (field research) recall the technique of Shot Put and perform several throws to get familiar with the specific skill. At the end, they record 3 throws per person by using tablets and Web 2.0 recording software (Coach’s eye). Furthermore, a team worksheet is given to the students to gather information

ISBN 978-615-5511-06-6

with the use of the ICT regarding the Olympic Records from the modern Olympic Games from 1986 onwards.

- Activity 2: the students with the help of two teachers (PE and CS), by using Web 2.0 tools (video editing software) they edit the recorded throws from the previous activity and upload them to the Wiki. They also create in a subsection of the Wiki a 3D modelling drawing contest (Web 2.0 tools- SketchUp).
- Activity 3: an interdisciplinary lesson with the Physics teacher. A video is presented of an Olympic Game Shot Put athlete followed by discussion. The students have to identify the forces that are present in Shot Put and to name the laws of Physics. Afterwards, they discuss about the ideal throwing trajectory and they use an online simulation in order to test the theory (Web 2.0 tools- PhET interactive simulations).
- Activity 4: same as activity 1 (field research), but with the recent knowledge of the laws of physics and the ideal throwing trajectory, the students perform several Shot Put throws and then they recorded again 3 throws per person by using tablets and Web 2.0 recording software (Coach's eye). Also, a team worksheet is given to the students to gather information with the use of the ICT regarding the different official techniques of the Olympic Shot Put.
- Activity 5: an interdisciplinary lesson with the Mathematics teacher. Once again the awarded short film of activity 1 is presented and the students try to imitate the "hero" of the film by solving a mathematical problem (from the high school Physical Education textbook). Afterwards they discuss with the teachers (PE and Mathematics) the solution of the mathematical problem and try to make a graph in x-axis and y-axis with mathematics software (Web 2.0 tools- GeoGebra, Cabri).
- Activity 6: same as activity 2 but with 2 set of recorded Shot Put throws, before and after the interdisciplinary lessons. By using Web 2.0 tools (video editing software), they edit all the throws and compare them with their own (initial-final) or with throwing attempts of other classmates.

In the third phase the final editing occurs. Also results and conclusions from the project are presented to the school community.

- Activity 1: in this activity the students make the final edit of all the educational material. They update the Wiki and discuss about presenting their project to the school community.
- Activity 2: in this activity the students present their project to the school community, the Parents' Association and other schools through Wiki.

Impact

The educational scenario had a strong impact on the students, the teachers of various specialties and the local community. The outcome was surprisingly positive, and the physical participation of the students increased from lesson to lesson. Inspired by the educational project, the students collaborated synchronously and asynchronously, combined conventional and innovative tools, used various research methods and created their own original material.

ISBN 978-615-5511-06-6

The students changed their attitude towards PE, as predicted, in a positive way. After the specific project they were open-minded in all kind of sports and more eager to try sport activities and understand the Physics, Biology or History of the particular sport activity. The teachers recognized the benefits of interdisciplinary lessons and the interaction between the various cognitive fields as the children asked after every law of Physics or Mathematical problem that was presented to them, to perform an experiment or to associate it with an everyday human activity. The presentation of the innovative school activities to the local community had also a great impact. They urged the school community not only to continue to perform similar projects but to assist in this direction when possible. This innovative practice, despite the fact that it was implemented in a small scale it seems that it can also be implemented on a larger scale. Through the use of ICT not only local schools and institutions can participate, but also foreign schools and universities from all over the world.

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

NANOTECHNOLOGY THROUGH LESSON PLANS IN 7TH GRADE OF PRIMARY SCHOOL IN CROATIA

Marina Molnar, Primary School Stobreč, Croatia

Background and Introduction

On April 29, I attended on professional workshop on Faculty of Natural Sciences a Mathematics in Split called "Nanotechnology: Digiskills – digital competence in education (inverted classroom)" where we were told about Project Digiskills. For development of scenario of good practice, on expert conference, I was curious about how much my students know about nanotechnology, especially about the term of 'Nano' and photography. The plan was to revise what is 'pixel' and what is the difference between photography and digital photos. Furthermore, is there any connection between nanotechnology and photography, how much nanotechnology have an effect on quality of photos and is there any effect at all, and whether photos be protected with assistance of nanotechnology?

Students were not excited about exploring connections between nanotechnology and photography/digital photography, but they were interested in enquiring nanotechnology in the field of medicine, cosmetics, environmental protection and robotics. Students discussed about the meaning of term 'Nano', and linking it with the curriculum of mathematics, physics, biology and chemistry. They explored areas in which nanotechnology can be developed as well as various nanomaterials that exist. Students were interested in finding answers to the question of how nanomaterials acts in medicine, cosmetics and environmental protection, as well as researching 'nanobots', especially where to used them in every day's life, and are they our future or present? They explored how nanomaterials acts on the environment, or if it have an impact on our health or health of our environment. After they collected materials students formed it into websites, mobile applications, online presentation and glogs.

The subject of Nanotechnology is very interested for me because it is less known and infrequently topic, especially between students of primary schools. What interests me the most is to explore something new and uncommon, so I am motivated to present my students some innovative ways of solving the problems, and finding solutions in various (online) programs. Mutual learning between the students results in, discovering affection in various fields of informatics; nonetheless, they are improving their skills and acquiring new competences, which is helpful for each other growth. My students and I are very grateful to our headmaster, psychologist, school librarian and other colleagues for their supports and interests in project.

Basic project information

The projects target group was the twelve students of seventh ‘a’ Grade of Primary School Stobreč who attended Informatics. Students are at the age of thirteen and fourteen years old. Implementation starts on April 30 until June 11 2015 through lesson plans envisaged by the end of the school year. The project is connected with curriculum of Math, Physics, Biology and Chemistry, and with curriculum of Primary School Stobreč named “Health, safety and environmental protection”. Technical requirements that are used in implementation are personal computer, projector, mobile phones, Internet, video player, web tools (Glogster), web services (Edmodo, e-mail), a web-hosting services (Weebly, IBuildApp), online software for creating presentation (Prezi).

Teaching units where implementation conducted:

- On April, 30 2015 – Revision of (Lesson: Web development) – 59, 60 hours;
- On May, 12 2015 – The structure of the Internet (processing of teaching material; exercise) – 61, 62 teaching hours;
- On May, 14 2015 – Other Internet services (processing of teaching material; exercise) – 63, 64 teaching hours;
- On May, 21 2015 – Other Internet services (exercise and repetition) – 65, 66 teaching hours;
- On May, 28 2015 – Internet service providers (processing of teaching material); Connect to the Internet (processing of teaching material) – 67, 68 teaching hours;
- On June, 11 2015 – Revision of (Lesson: Web development; Internet); Justification achievements and concluding scores – 69, 70 teaching hours.

Key words: Nano, nanotechnology, nanomaterials, nanobots, Nano substance, Nano-medicine, public health, environmental protection, Nano cosmetics, websites, mobile applications, interactive posters/glogs, Internet, web tools, web services, online presentation.

Key words of the curriculum for primary schools:

- Acquaint interface, text and background, insert graphic elements;
- Index page, the text as a link, the image as a link;
- Graphics and backgrounds, simple tables, formatted text;
- The structure of an HTML document, HTML document tags (tag), simple HTML page description;
- Tag P, tag A, tag IMG;
- Planning the structure of the page management structure, compilation and publication of the page;
- Server, client, communication methods;
- Remote file transfer (FTP);
- Internet access; hosting of websites;
- Types of modems, modem role.

ISBN 978-615-5511-06-6

Educational achievements: Use of new web tools and web services. Creating an online web page (Weebly) and publishing it. Creating an online mobile application (IBuildApp) and transfering it on mobile device. Creating an online interactive poster (Glogster) and connect it with website. Creating an online presentation (Prezi).

Educational achievements of the curriculum for primary schools:

- Make a simple personal website;
- Insert a picture element in website and turn it into a link to another page;
- Use the table as an element of the Web page;
- Interpret simple HTML page description;
- Be able to add parameters to the basic tag;
- Formulate the structure of the page;
- Be able to explain the methods of communication within the Internet;
- Describe the described Internet services;
- Explain the role of the server;
- Explain the need for faster Internet connections in the future.

Learning outcomes:

Students will be able to:

- Appoint the initial and most important page on the website;
- Describe what is the web page;
- Identify and know the meaning of the abbreviation of HTML;
- Compare as graphic (HTML) editors;
- Define acronym WYSIWYG;
- Describe code with which we can connect the two sites;
- Determine what kind of image format to use when creating a web page;
- Describe the tag used to display the image in an HTML document;
- Describe tags for the title; the letters that are bold, underlined and italicized;
- To become conscious of how to create a new HTML document;
- Describe which command create a new link;
- Distinguish between tags <html>, <head>, <title>, <body>;
- Explain why the tags have their final tag;
- Explain the elements that make up the table;
- Identify the structure of the Internet and the ways of communicating with it;
- Explain the structure of the Internet and the role of the server;
- Evaluate the quality of the content and process know contents from the Internet;
- Explain the modes of the communication within the Internet;
- Explain the protocols for communication;
- Describe what is www (World Wide Web);
- Explain the structure of the Internet and terms the client and the server;
- Explain the role of the server and list server types;
- Itemize and describe the various services of the Internet (Forums, FTP, Chat, E-Learning, E-mail);

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- Distinguish the tools of Web 2.0;
- Distinguish between social networks and their advantages and disadvantages;
- Develop your own interactive posters (Glogster);
- Develop web page using a web-site builder Weebly;
- Develop mobile applications using a web platform IBuildApp;
- Create an account on a social networks for students (Edmodo) and use it in classroom or from home;
- Use one of the basic service of the Internet – E-mail;
- Use a tool for sharing videos – YouTube – students can find videos of nanotechnology and nanomaterials that are appropriate, interesting and understandable to them;
- Publish your site on the Internet;
- Explain the meaning of the FTP service;
- Explain the role of the modem;
- Explain who are service providers (ISP);
- Explain the hosting of web page;
- Explain what is necessary for creating an account (username, password, e-mail address);
- Explain how to connect to the Internet;
- Explain the term of 'Nano', nanotechnology, nanomaterials and Nano computers;
- Explain in what area we find nanotechnology;
- Explain term 'bit' and contradistinguish with 'Nano bits';
- Comparing the 'Nano' and 'bits';
- Relate nanotechnology with other subject: Math, Chemistry, Physics, Biology and everyday life;
- Explain what is the 'Nanobots';
- Explain the role of nanomaterials in medicine, cosmetics and in nature conversation and environmental protection;
- Use and develop an English language in the classroom and applying it in everyday life.

Activities and innovative solutions of resolving informatics problems

Revision of Lesson: Web development

Introduction: Asking students did they heard about nanotechnology? Do you know what is 'Nano' and what does it mean? We watch a YouTube video called "What is Nano?" [1] Emotional break. Conversation about video: How small is 'Nano'? From what material is it made of? Where we can find it in everyday life? Do you think that nanotechnology is our present or future?

Presentation (demonstration with computer and projector): Today, we have revised lesson "Web development" on the way we did not revise yet, through creating a web site with assistance of web-site builder called Weebly[2]. (Revise what HTML and WYSIWYG means.

[1] YouTube video: https://www.youtube.com/watch?v=Dxq-ffp3jqA
[2] http://www.weebly.com

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What signify 'www'? What for serves web services? What are web browsers? Can you name famous web browsers?) For start, we created an account on Weebly and where students have to know their e-mail addresses and passwords, and then had to login theirs account. (Student works in parallel.) Weebly offers us a possibility of creating web sites, blogs or online stores. (Revising what is web site. In which way have we learned to create a web site? In which programs?) We pick up creating 'site'. The students pick up custom theme, which best fits to nanotechnology. (We must be careful of picking themes because different topics requires appropriate theme. Revising how we called main page of web site and what is 'tag'; what is the tag for begging and the end of web page[3].) Describing the look of web builder: On the left side is toolbox with elements of the web page. First tab, on the top of the web builder is call 'Build' with all its elements. (Revising the elements of the web page.) Second tab, 'Design', help us to pick up custom themes, font types, adding social networks, possibility for amending design of web page with HTML/CSS code, etc. (Revising code for bold, italic and underline letters[4], and font types and colours[5]. Repeat code for background colours[6] and background image[7].) Third, tab 'Pages', marks pages within our web page, which are their integral part. (Revising in which way we must create our new page inside web page in Notepad/KompoZer or Notepad++[8]. What tag we used to insert an image[9] in web page?) Revising what is the benefit of tags <head>, </head>; <title>, </title> and <body>, </body>. In Weebly, the title will be showed in the part which is called 'My site' and it will be visible on web browser title bar. We can insert our logo, pictures or pictures galleries, audio and video, maps with locations, documents, other pages on Internet, and so on. Every element on the web page we can extra formatting, editing or shaping. The body of the web page we are shaping with 'drag and drop' of elements or picking up provided template.

Practice: Students divide in pair. They must explore what is 'Nano', nanotechnology and nanomaterials. In pair, they must design how would their page look like, start to create web page, which they will continue finishing through other lessons we will learn.

Evaluation: Presenting the ideas and materials what they found about the task. Revising all that we learn today.

(**Homework**: Share students' paperwork: Explore where we use nanomaterials and in which area is best implemented in our lives. What is 'pixel'? What is photography/digital photography? What is digital museums? Is there connection between photography a nanotechnology? If there is any connection, can we protect photos with nanotechnology?)

Review of the lesson: Students are impressed with video about 'Nano' and all area of nanotechnology. The video show them how nanoparticles are tiny and invisible in our eyes.

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[3] <html>, </html>
[4] , ; <i>, </i>; <u>, </u>
[5] Example: Web page
[6] Example: <body bgcolor="blue">
[7] Example: <body background="background.jpg">
[8] Creating new HTML and link it with tags, for example: Yellow page
[9] Example: <img src="picture.jpg"> or <img src="picture.gif">

ISBN 978-615-5511-06-6

The students shows interest for entirely area of nanotechnology, from what kind of material they build of, in which objects can we find them. Schoolgirls showing interest for Nano medicine, especially if is there any nanomaterials that exist in cosmetic Have it had any effect on our everyday life? Can it be wrong for our health and environment? Schoolboys are interested in nanobots, especially for the fields like where we can find them, what does it look like? From all homework, I got just one presentation about the topic, but a bunch of material of Nano medicine, Nano cosmetics, nanobots. So, I decided to accept what the students are interested in.

Lesson: The structure of the Internet (processing of teaching material; exercise)

Introduction: Students expose their homework. Where did you find all information? Today we will learn more about Internet, and revise what you have learned in fifth and sixth grade.

Presentation (demonstration with computer and projector): We talk about Internet with help of presentation called Internet.pptx (On my website[10]: Internet.pptx). What is Internet? How would you describe it with your own words? What is the history of the Internet? Why is Internet so successful today? (Students gives ideas.) I am explaining how Internet works using the animation (Figure 1). We compare connections between Server – Internet – Client with nanoparticles that connected with Nano relations and transfer data, almost the same like Internet. I am explaining students server types and transfer protocols (www server, e-mail server, FTP server, DNS server; TCP and IP protocol, HTTP protocol, SMTP protocol and POP protocol). Students suggesting if they have met with addresses of computers. (Server have a static address, while client have a dynamic address. With every connection to the Internet, user computers get a new address.) Every computer on the Internet and in network must have its unique IP address. (Computer address consist of four groups of binary numbers separate by period, which we write in decimal system because of ease of memory.) Symbolic addresses[11] are easily to remember and comprehensible.

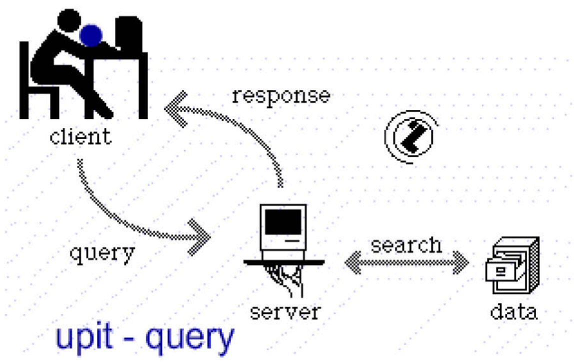

Figure 2. Server – Internet - Client

[10] http://7thgradenano.weebly.com/
[11] For example: www.os-stobrec.skole.hr

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Practice: Revising through two exercise on which way to read our computer address and address of web site. Control and explanation of solved tasks. Revise how we share types of network. Now that we know how the structure of Internet is, do we know how a structure of nanoparticles is? Whether these two different things are similar in many ways? Work in pair: Explore interesting facts about nanomaterials, Nano medicine, Nano cosmetics, nanobots, protection of environment with nanotechnology. Continue to update their web sites.

Evaluation: Analysing of work that is done. Revising of what has been done.

Review of the lesson: As time goes by, students are more interested in Nano products, nanobots, Nano medicine, Nano cosmetics, Nano environmental protection. They found many YouTube videos about the topic. Students are interested in whether there are some kind of drugs that can prolong a person's life, or are there any nanoparticles in sun creams, as well as how to look like nanobots and how nanobots are made, how it effects on environment protection, etc. Two students were sick, so I continued working with ten students.

Lesson: Other Internet services (processing of teaching material; exercise)

Introduction: Revising what has been taught the last teaching hour: What is Internet? How originate the Internet? Why is the Internet so successful? How does Internet work? What types of server do you know? Explain every one of them. What is computer address? What type of address use user computers, and which one use servers. According to what kind of criteria, we divide networks? What protocols do you know and on what way does protocols work? Do you find something new and interesting from area of nanotechnology? Students talk about found data. Today, we are going to learn about other Internet services.

Presentation (demonstration with computer and projector): Do you know what the main services of Internet are? What is 'www' and e-mail? We talk about Internet with help of presentation called Other_Internet_services.pptx (On my website: Ostale_internetske_usluge.pptx). I explained to students other Internet services, that they knew (like E-mail, Facebook, Twitter, and new one Edmodo[12]) to less known or unknown social networks. What are the advantages and disadvantages of social networks? Together, we create our virtual classroom on Edmodo and in the future we will use it for submitting homework, asking questions from home, to explain some of unclear part of material, etc. Continue with other Internet services: I explain is what blog, forum, E-learning, Chat, web site hosting and VOIP. Students are amount experience of listed services. Do you know what is FTP? (File Transfer Protocol) Do you think that is the only way to transfer data? We downloaded data directly from link on web page, and FTP we mainly used for web hosting web pages on remote server. Except for Internet services, Internet offer web tools to us. First web tools were one-way where you can only save web page or read it. Today, almost every content on Internet you can share, comment, take over on yours web sites, they are interactive and we call them web 2.0[13]. *For those who want to learn more: Tools of web 3.0 network*

[12] Social network for students and teachers.
[13] For example, Wordle, Glogster, wiki collaborative tools.

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knowledge. It is often called 'semantic web' because in really short time it will include intelligent browsing and looking information on what basis can decide to what group of the users belongs to the area of interest. Users will be able to submit information regarding the browsing and searching. Example of web 3.0 is Powerset browser. Together, we have found Powerset browser, and students express their explanation about what it means and would that help us in our searching for information. One of web 2.0 is Glogster[14], which is used for creating online interactive posters. Creating account with students and logging in. In Gloster, we created a glog in which we can pick custom themes, added text, pictures, audio and video, documents, link to the other pages, etc. All that elements of glog, we can edit on the similar way as we do that in Weebly.

Practice: Create a glog about the interesting topic from nanotechnology. *For those who want to learn more: Creating mobile application in online platform IBuildApp*[15]*. For creating a mobile application, we need to make a registration and login in IBuildApp. First we create template of our mobile application, and it will show us the main page of application, or we can use custom templates. You can edit buttons of application, and make it that have backgrounds image or another colour of text. When we are done with creating template, we go to create an application according to template. For creating application, we can use button 'Change feature' which can make changes in characteristic, for example from HTML5 into template of offered applications (photoallergies, videos, adding social networks, and so on.) When our mobile application is done, we can transfer it to our mobile phone. If somebody wants, you may start creating a mobile application about nanotechnology, nanomaterials, nanobots, Nano in environmental protection, Nano medicine, Nano cosmetics.*

Evaluation: Analysing and presentation of created interactive posters in Glogster. Presentation of started mobile application. Revising learned.

Review of lesson: Some students are more interested in creating interactive posters, in general of Nano medicine and Nano cosmetics. Other students started turn on creating mobile application, in general about nanobots and nanobots in nature.

Lesson: Other Internet services (exercise and repetition)

Introduction: Revise what are Internet services, which one you know and which one you used to. Explain what is VOIP, social networks, FTP and E-learning. What are web tools? What is the difference between web tools and web 2.0? Which one of the web 2.0 tool we use to?

Presentation (demonstration with computer and projector): *For those who want to learn more: Making online presentation with online software Prezi*[16]*. Prezi is located in cloud on the Internet, which means that we have space on Internet where we can make our presentation. Software is make as virtual canvas that you can zoom. On virtual canvas, you can put objects as*

[14] http://edu.glogster.com/?ref=com
[15] http://ibuildapp.com/
[16] https://prezi.com/

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pictures, videos, text, etc. For start, we must create an account and then login. Choose 'New Prezi' to start making a presentation. It will open a template of a possible presentation or we can choose an empty one. The title of presentation write in box 'Click to add title'. In the box on the left side are virtual canvases like in Microsoft PowerPoint. Selecting a roll, whether insert text, while drop down menu called Insert, allows inserting pictures, shapes, symbols, YouTube videos, background music, PDF documents, presentations, etc. Drop down menu 'Customize' allows changing themes from templates or from our computer. All objects can be subsequently formatted.

Practice: In pair, choose between making online presentation – Prezi, making a mobile application – IbuildApp or making a website – Weebly. The topics are: "Nanotechnology", "Nano medicine", "Nano cosmetics", "Nanobots" and "Nanobots in nature (in environmental protection)". Web sites you started to work, you can continue. If you choose Weebly, it is important to connect it with interactive poster made in Glogster.

Evaluation: Analyses of schoolwork and revising learned lesson.

Review of lesson: Students spontaneously began to discuss about prolonging person's life. Patient would be given fluids containing nanorobots programmed to reconstruct the molecular structure of viruses and carcinoma. Each advocated for this problem, and other against. They asking each other questions as what happen to people, is there enough food for prolonging life, how would people live. Someone said that would not be good because it would have an effect on order in nature. Students were enthusiastic with new software Prezi, and creating on that way a presentation. They said that is interesting way to create a presentation, better than using Microsoft PowerPoint.

Lessons: Internet service providers (processing of teaching material; exercise); Connect to the Internet (processing of teaching material; exercise)

Introduction: Revising what we learned about web sites. In which web builder did you learn to create web site? (Weebly.) Today, we are learning about the service providers on Internet as well as how we are going to publish our web site.

Presentation (demonstration with computer and projector): We used the presentation called ISP_and_Connect_to_the_Internet.pptx (On my website: Davatelji_usluga_na_Internetu_i_Povezivanje_na_Internet.pptx). I am explaining to my students how the companies whose main job is to give access to the Internet names service providers or ISP. The most widely companies in Croatia are CARNet, VIP and T-Com. CARNet is unchargeable service provider. To connect to the Internet we will be needing an open account at one of the service providers. The user account contains username, password, e-mail address and, often, a web hosting space for web sites. Web hosting means setting up web site on remote computer, which is available 24 hours, 7 days in one week. Such computers are named web servers or www server. In transfers web sites, we used FTP protocol. Revise what is the FTP protocol. There are countless examples of web hosting, as www.free-space.net, www.x10hosting.com, www.weebly.com, etc. Disadvantage of every free web hosting is that they can stop to be free or stop offer a web hosting. Schoolwork: With help of Weebly, we were publishing web pages. (Steps are on presentation.) Verification of published web pages. What do you think, what do we all need for connection to the Internet? (Computer/tablet/mobile phone/etc., user account at service provider and device for connection to the Internet.) Revising what is 'bit'? Before, people used the analogue modems which was used a DIAL UP connection. What that means? Our computer must to adjust to call number that is given by operator and that keeps our telephone line was busy. The roles of the modem is to MODulate data in computer for transfer through telephone wire, and later DEModulate data, i.e. again adjust showing on another computer. Modem was digital data from computer, turn in analogue data for transfer with telephone wire, and turn it back in digital shape on another computer. ISDN (Integrated Services Digital Network) modems are a little bit faster than analogue, and are using two telephone lines. Signal was not modulate from digital to analogue, rather was already transferred in digital shape. The time spent on the Internet was measured, and thus that charged. DSL (Digital Subscriber Line) have been used for all time connection with the computer. It measure the amount of data which our computer transfer with server. ADSL (Asimetric Digital Subscriber Line) have an opportunity of wireless connection with Wi-Fi card. Internet access is required to protect with password, because other devices can use our traffic data. FLAT RATE is subscription with unlimited traffic data. Mobile connection, in addition of voice services and messaging, offer us data traffic.

Practice: Finishing the web pages, mobile applications, presentations, correct the mistakes and train display for presentation.

Evaluation: Revising the today lessons.

Review of lesson: Students finishing their works. They are enthusiastic about their web pages they can show their parents that they done in class.

Revision of Lesson: 'Web development' and 'Internet'; Justification achievements and concluding scores

Introduction: Revising all about Internet and Web development: What is Internet? Why is it successful? How does Internet work? What are servers and clients? What is IP address? What is the difference between static and dynamic address? Enumerate types of protocol. What are standards for data transmission? What are TCP protocol and IP protocol? Which protocols are using www server and which one FTP server. Explain the difference between SMTP protocol and POP protocol. What is the most popular services on the Internet? Explain VOIP. What kind of the social networks have you known so far and enumerate them. What are advantages and disadvantages of social networks? What are web tools? What is the difference between web tools and web 2.0 (web 3.0)? What is Glogster and glog? Who are service providers on the Internet? What user account contains? What is web hosting? Enumerate some free web hosting. Which web site builder we use to publish our web pages? What do we need to connect to the Internet? What is the difference between analogue and digital modems? Explain the role of modem. Why is it important to protect our network with password?

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Presentation: Students exposed everything that they have learned about Nanotechnology, term of 'Nano', nanomaterials, Nano medicine, Nano cosmetics, Nano products, Nano in environmental protection, Nanobots. Students transfer mobile application on their mobile phones and test how its work.

Practice: Displaying completed work. Assessment scores.

Evaluation: Explanation of the success achieved during the year, concluding assessments and explanation of individual achievements and final assessment of the individual student.

Review of lesson: Students displaying final works. They make a three web pages in web site builder Weebly. With their web page, they were connected to YouTube videos, interactive posters which are made in Glogster, also they were able to link other pages on the Internet, and all material that was interesting to them about nanotechnology. Also, they made one presentation in Prezi who talk, in general, about nanotechnology and nanomaterials. For the end, they made two mobile application in IBuildApp.

Final works of students in 7th grade:

- Petra Cokarić i Katarina Kolovrat: Weebly&Glogster – http://nanomedicina.weebly.com/;
- Katarina Garac: Weebly& Glogster – http://nanoproizvodi.weebly.com/;
- Paulina Grčić i Magdalena Brekalo: Weebly& Glogster – http://nanokozmetika.weebly.com/;
- Marijo Gajšak i Stipe Bilonić: IBuildApp – Aplikacija_o_nanobotima.docx;
- Marino Kovačić: IBuildApp – Aplikacija_o_nanobotima_u_prirodi.docx;
- Antonela Sičenica i Barbara Blažević: Prezi – nanotehnologija-5pja82ibubtb (zipped folder).

Note: All lesson plans, presentations and students work you may find on my web page http://7thgradenano.weebly.com/.

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ISBN 978-615-5511-06-6

ISBN 978-615-5511-06-6

SAFER INTERNET PROJECT

Jasminka Lisac, Branka Mihajlović, Srednja škola Delnice, Croatia

Background and Introduction

Delnice High School is a school located in a mountain region of Croatia. Although it is a small school, its students and teachers are often involved in various projects and activities such as Safer Internet Project through the Digiskills National Competition.

This competition was a great challenge and an opportunity to improve our usual teaching methods and skills. It also improved collaboration between subjects and teachers, in this case between the Croatian language and Computer science. As teachers, we had the opportunities to create something different, outside the box, rather than simply following the national curriculum. We may say that this competition was a great opportunity to create something new and useful.

Safer Internet Project:

- Srednja škola Delnice;
- methods: self-learning, group learning, gamification, flipped classroom;
- classes: 1st , 3rd and 4th grades of secondary school;
- mentors: Jasminka Lisac, Branka Mihajlović;
- duration: 3 hours.

Phase 1 – Motivation

The motivational video was made by 3rd grade students through "Dislike the hate on the Internet" national campaign. The campaign was initiated due to the fact that the Internet has become the media used to spread hate, mobbing, bullying, insults, etc. The key sentence is a quote by one of our students, Bruna Kanjer – "Internet wasn't created to bully others".

- https://www.youtube.com/watch?v=U0L8vlc-9Og
- http://portal.opendiscoveryspace.eu/node/832416

Phase 2 – Lecture

MSc Bernard Vukelić, a university professor from the Polytechnic of Rijeka was a guest lecturer that introduced the topic of safer Internet in a lesson entitled "Biometry and the Internet safety". The main aim was to point out the dangers and possibilities of controlling and tracking the Internet users. The lesson was held in the school library on June 12, 2015 for the 1st and 4th grade students. The special attention was given to biometry, cookies and other methods of tracking Internet users.

Figure 1. MSc Bernard Vukelić – Biometry and safer Internet, school library

Phase 3 – Flipped classroom

The final grade students had a task to educate the 1st graders about the dangers of Internet. They created and presented PPT lessons mainly from the aspect of Computer Science. The most successful presentation was held by a senior student Bruno Svetličić, as selected by the authors themselves because the entire project is conceived as collaborative teaching and mutual cooperation between older and younger students.

- https://www.dropbox.com/s/384sekfwozfqcvn/PREZENTACIJA-ZIS.ppt?dl=0
- http://portal.opendiscoveryspace.eu/node/832413

The first grade students conducted the valorisation and gave feedback to their senior colleagues. They created mind maps and posters covering topics from the PPT lesson while showing their own creativity.

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Figure 2. Ana Frković, the 1st "e" grade, Safer Internet poster

(A student Ana Frković created her own visualisation of Svetličić's PPT – she draws viruses coming from the Trojan horse and causing damage to the title chain – a symbol of damage by a computer virus. The poster includes potential dangers such as gambling, paedophilia, false profiles, etc.)

Phase 4 – Fun and learning

Safer Internet comic lesson

Students and teachers used the Pixton comic application and created comics to express their own points of view on this particular problem – different topics such as cybercrime, cyberbullying and others were covered.

- http://portal.opendiscoveryspace.eu/node/832414

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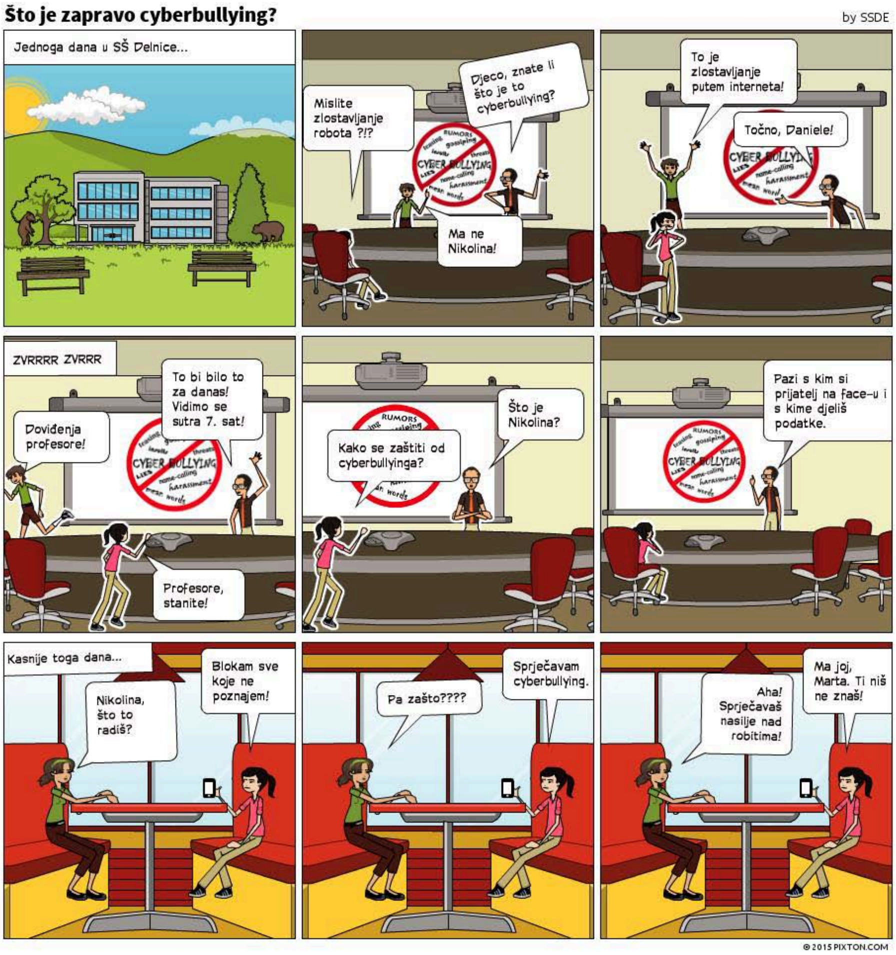

Figure 3. A comic by Klara Kastner and Andrej Beljan, the 3rd “b” grade

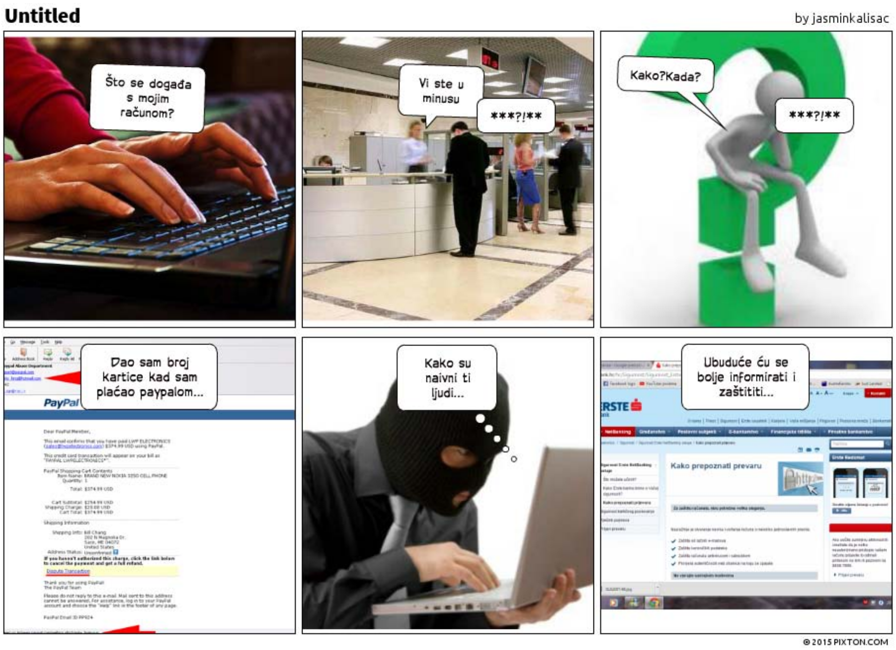

Figure 4. A comic by Jasminka Lisac, Croatian language teacher

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Phase 5 – Valorisation

Valorisation – crossword puzzle

Mentors involved in the project created the crossword using the Internet safety key words and terminology.

- file:///C:/Users/Korisnik/Documents/sigurnost%20na%20internetu/~TempJCrossPrint.htm
- http://portal.opendiscoveryspace.eu/node/832415

Mentors organized a workshop for the most curious students in order to further explain less known problems. The main goal of this particular workshop was to share students' own experiences and openly talk about the potential dangers and unpleasant situations in our own community, especially the school itself, mostly involving social networks such as Facebook, Twitter and Instagram.

Phase 6 – To be continued

Video workshop

The 3rd grade students created a short movie. They came up with short questions about topics and terminology covered during the project and used Scrabble as a fun and innovative method to educate elementary school students. The main goal of this project was to include students of different ages and to provide them with the opportunity to teach and learn from each other. This phase is not the end of the project because it is meant to enable the transfer of knowledge from the university level to the kindergarten providing us with numerous options to continue this project on different levels.

- https://www.youtube.com/watch?v=p4n42r7WlNE&feature=youtu.be
- http://portal.opendiscoveryspace.eu/node/832411

Conclusion

As project creators, our main objective was not only the topic of safer internet, but we have also tried to highlight the teaching methods: from university to high school, elementary school and kindergarten.

The project was created like an open circle based on knowledge of university experts such as Mr Bernard Vukelić through the idea that older students teach younger ones. We are all aware of the fact that older student are teenagers' idols, so we try to use this fact to improve our lessons and influence the younger population.

Internet as a new and modern media has enormous impact on the modern world – very positive and also very (potential) negative and dangerous one. Our idea was to warn students about real and potential dangers and we hope that modern and interesting methods like crosswords, comics, even making movies will help us raise awareness.

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This project is the result of team work of many people – we are very thankful to Mr Vukelić, our school's ex student and university professor who very kindly responded to our invitation and as expert in this area held a lesson in our school library. Also, many students had a key role in this project and helped in realization with their motivation and dedicated and creative work.

After all, this project hasn't finished because this topic is always present and it is necessary to talk, warn, speak and point out to our students the dangers of the Internet in every possible way. So our main conclusion is that we will continue our work using new methods and sharing experiences with other schools and teachers.

Proofreading for the English language and typos

- Una Matić Vukelić, English language teacher;
- Davor Pleše, English language teacher.

References:

- Authors' work.

ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

AN INTRODUCTION TO THE GEOMETRY OF FRACTALS IN PRIMARY AND SECONDARY EDUCATION

Konstantinidis Ioannis, School of Pedagogical and Technological Education of Athens, Greece

Introduction and Background

In the course of classical geometry in school we learn about lines, circles, squares, cubes, cylinders and spheres. In nature, however, other shapes prevail around us: clouds, lightning, ice crystals, sponges and shoreline exhibit a complexity that looks nothing like the simple geometric objects of "classical" Geometry [1].

In this article, we try to see the world around us through a different prism, that of fractal geometry (Fractals). In particular, we present below a model for a lesson scenario and simulation called "Fractals for High School students".

We took the idea (exemplified by the so-called "Pythagorean tree") to describe the world using a geometry more complex than the one usually presented in schools, because such a geometry represents the true reality around us. Such a knowledge about the surrounding world will hopefully render the pupil's perception of the world better and more complete. Therefore, we propose that the notion of complex geometry will render our students more creative, open new pathways of thinking, and motivate new activities in life.

Description of Lesson's Plan

The lesson scenario presented in ISE (Inspiring Science Education – http://portal.opendiscoveryspace.eu/el/edu-object/mia-eisagogi-stin-morfoklasmatiki-geometria-fractals-829770) is an attempt to introduce a way of thinking more "complex" than the one students are so far exposed to in school.

As a teaching method, we apply the so-called Inquiry Based Learning [4], consisting of five stages.

In the first stage, the student is mobilized and oriented towards the main theme of the course, being invited to explore the issue of fractal geometry (or fractals).

In the second stage, the main assumptions as well as preliminary notions about the central course's theme are given, while the student is now invited to start designing the students' own Pythagorean tree.

In the third stage, the students are introduced to using the simulation called "Pythagoras Tree", developed specifically for the needs of the hereby proposed lesson scenario. Thus, the student becomes now actively involved in the idea of fractal geometry and makes a first research on the topic, using both the simulation as well as internet resources. Finally, the student is asked to record his/her own findings in a notebook or in a computer Word document.

The fourth stage consists of the analysis and interpretation of the student's research findings, where discussion on the subject of fractal geometry now takes place between the student and the teacher.

Finally, in the final stage, the student concludes, building upon the knowledge gained, end exploring possible new applications. The teacher triggers now the interest of the students in studying further topics related to fractal geometry.

Description of the Simulation

The "Pythagorean tree" [3] is a fractal geometrical set devised by the Dutch mathematician Albert E. Bosman in 1942 [2]. It is named after the ancient Greek mathematician Pythagoras, because it is based on putting together so-called "triads of squares", i.e. squares satisfying the property that in every newly formed triad, the squares' vertices are joined so as to form a right triangle. This configuration is the basis of proof of the Pythagorean Theorem. In the classical Tree of Pythagoras, setting an angle of 45 degrees, we join triads in a way so as to form new branches and extensions of the tree. This shape is often called the "Windswept tree of Pythagoras". If, instead, you only represent parts connected in any way, choosing the corresponding centres of the triangles, we form the so called "naked" Tree of Pythagoras.

The simulation which we developed is called *Pythagorean_tree.jar*. Its use helps the student to experiment dynamically and form a student's own opinion about the concept of fractal geometry, studying the Pythagorean Tree. The image given in Figure 1 shows an example of a pattern formed after running the simulation.

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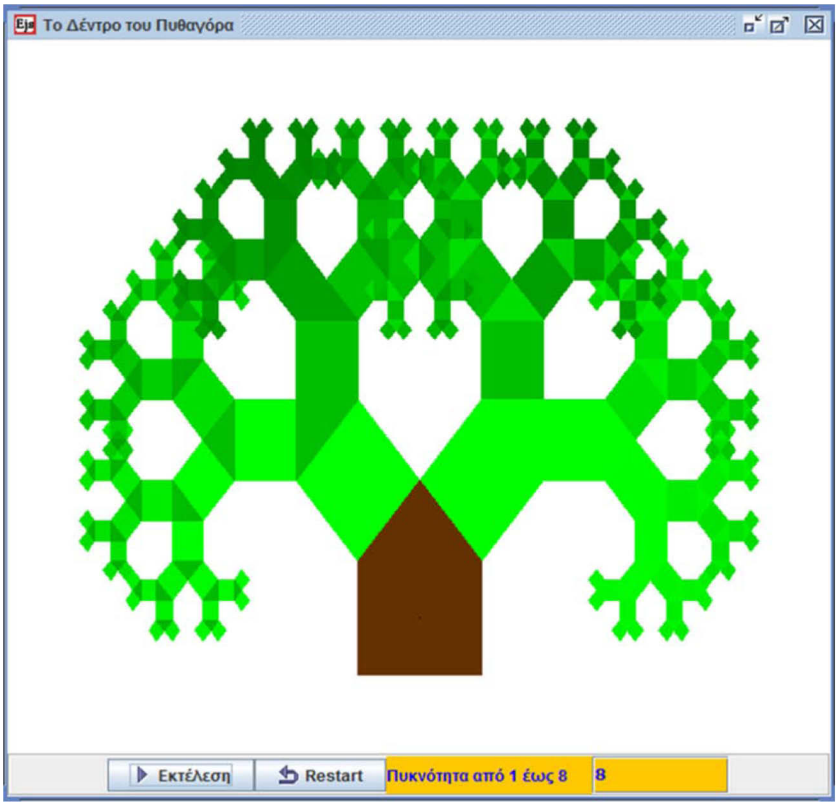

Figure 1. Pythagorean Tree from Simulation

Algorithm of construction of the Tree of Pythagoras

- Step 1: Create an initial rectangle.
- Step 2: In the upper ends of the initial rectangle build two new rectangular blocks with fixed angles (specified by the user).
- Step 3: Repeat steps 2 and 3 for all new rectangles until a Tree is formed.

The figures below show further examples of Pythagorean Trees formed by different parameters' choice in the simulation.

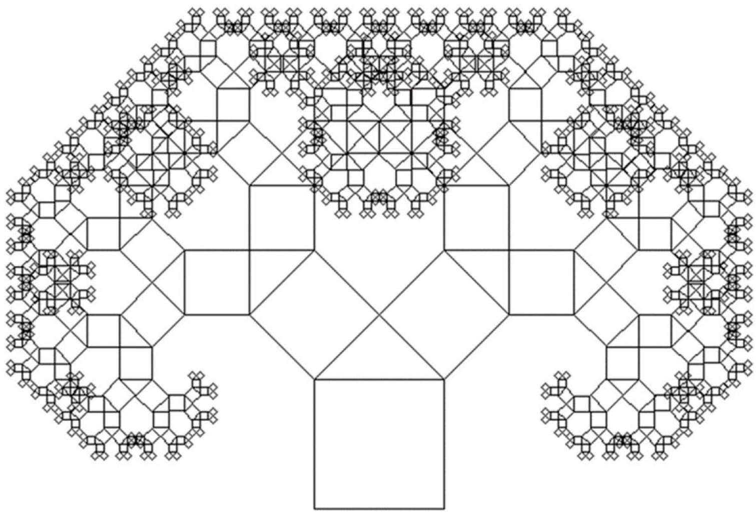

Figure 2. Classic Tree of Pythagoras

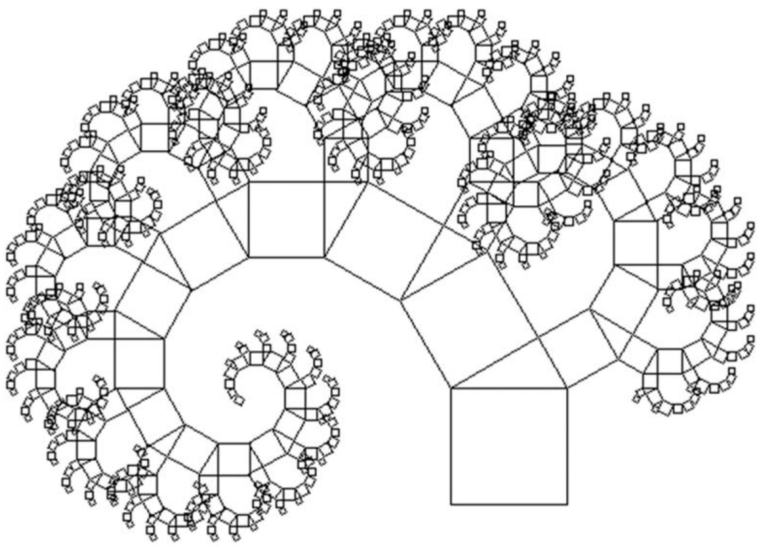

Figure 3. Windswept Tree of Pythagoras

Conclusions

In this article we have tried to outline the main points on the course scenario of fractal geometry so as we planned with ISE Authoring Tool. Also we gave the algorithm of Tree of Pythagoras and simulation to support the school lesson from teachers.

In conclusion, we believe that after this course the student will have another view of the surrounding nature. The student will be able to understand and describe a more "real" way the reality around him.

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
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ISBN 978-615-5511-06-6

THE COMPUTATIONAL EXPERIMENT USING THE EASY JAVA SIMULATION COMMUNITY AND THE INQUIRY BASED LEARNING AND TEACHING APPROACH

Sarantos Psycharis, Kyriakos Syrmakezis, School of Pedagogical and Technological Education, Greece

Abstract

In this study, an instructional design model, based on the computational experiment approach, was employed in order to explore the effects of students' engagement in the development of inquiry based pedagogical scenario.

Our preliminary results indicate that the development of models of simulation is a process that needs sequencing and instructional support specific to the scientific abilities needed for the inquiry process, and this process can be supported by the involvement in a community of practice.

This research was conducted in the Academic Year 2014-15 as a preliminary research at the Higher Education Institution-Faculty of Pedagogical and Technological Education-ASPETE and forty five (45) students participated as volunteers in order to be involved in the Community while some of them developed their pedagogical-inquiry based scenario.

Introduction

Scientific Abilities and the Inquiry Based Teaching and Learning

Recent research for educational reform in STEM education stresses the need for innovative teacher education reform in order to ensure that pre-service teachers not only gain understanding of how to use the technology but also of how to develop scenarios that integrate computational thinking and contemporary learning theories (Brush et al., 2003; Angeli, 2005).

According to (Etkina et al., 2006) "students should be engaged in scientific abilities, like: to identify questions and concepts that guide scientific investigation; to design and carry out scientific investigations; to use computational methods and mathematics to create algorithms; to formulate and amend scientific explanations and models using logic and evidence; to recognize and examine alternative explanations and models; and to communicate and defend a scientific argument".

Research also in STEM education suggests that scientific abilities should include: the capacity to represent physical processes in multiple ways; the ability to plan, test or modify a qualitative explanation or a quantitative relationship; the ability to design an experimental search; the ability to collect and analyse data, the ability to evaluate experimental predictions and outcomes and the ability to reflect on the cognitive strategies followed for problem solving.

To support learners developing these abilities, instruction should engage learners in appropriate teaching and learning processes that should enhance students' engagement in developing their own scenario.

Inquiry based learning is considered as a pedagogy for improving STEM disciplines learning in many countries (Bybee et al., 2008) and can be defined as "the deliberate process of diagnosing problems, critiquing experiments, distinguishing alternatives, planning investigations, researching conjectures, searching for information, developing models, debating with peers, and forming consistent arguments" (Bell, Hoadley & Linn, 2004) which are clearly related to scientific abilities. Inquiry based learning is often considered as a way to implement in schools the scientific method (Levy et al., 2010; Minner, Levy & Century, 2010). (Bell et al., 2010), identified nine main science inquiry processes, supported by different computer environments, that could be used in inquiry-based STEM disciplines, namely: orienting and asking questions; generating hypotheses; planning; investigating; analysing and interpreting; exploring and creating models; evaluating and concluding; communicating; predicting. The nine inquiry tools of (Bell et al., 2010) are related to the essential features of Inquiry (Asay & Orgill, 2010), namely: Question (Learner engages in scientifically oriented questions), Evidence (Learner gives priority to evidence), Analysis (Learner analyses evidence), Explain (Learner formulates explanations from evidence), Connect (Learner connects explanations to scientific knowledge), Communicate (Learner communicates and justifies explanations) and Reflection(Learner reflects on the inquiry process, respond to his/her work).

Inquiry Based learning and Models of simulation

In almost all inquiry based documents, models have consistently been recognized as one of the major unifying ideas that transcend disciplinary boundaries and permeate all STEM disciplines (National Research Council, 1996).

According to (Jonassen, Strobel & Gottdenker, 2005) a model is an artefact representative of a real object or of an internal interpretation of something real, often represented on a computer screen as a simulation.

In STEM education time dependent models are used to reveal the increased complexity of physical processes and the teaching process is organized into modelling units, which move learners systematically through all phases of model development, inclusion of variables, time dependent equations, and refinement of the model based on the analysis of data.

ISBN 978-615-5511-06-6

There is a clear difference between modelling and simulation, which sometimes is not easily detectable. According to (Xie, et al., 2011) we should differentiate the terms "modelling" and "simulation". When studying the function of a system that involves time depending properties, we should use the term "simulations" and if only the structure or configuration of a system is concerned, we should use the term "models".

According to (Jonassen et al., 2005) simulation is an executable model in connection with computer-software that allows a learner to handle variables and processes and observe the outcomes.

The Computational Experiment

According to (Landau et al., 2008) the ensuing decade has strengthened the view that the Physics community is well served by having Computational Physics(CP) as a prominent member of the broader computational Science and Engineering (CSE) community. Computational Science is the use of Mathematics and Computer Science to explore "real world" problems in STEM disciplines and is a multidisciplinary activity, which brings together concepts from a variety of disciplines.

According to (Vojta, 2006) Computational Physics (CP) is the 3rd independent scientific methodology that has arisen over the last 20 years or so, while it shares characteristics with both theory and experiment, and requires interdisciplinary skills in Science, Mathematics and Computer Science. He also clearly states that Computational Science is completely different from Computer Science.

Landau and Yasar (2003), state that Computational Science (CS) sometimes denotes the multidisciplinary use of computational techniques, tools, and knowledge needed to solve modern Scientific, Mathematical and Engineering problems, at other times it denotes Science or Engineering that uses computer simulations as its basis, and sometimes it denotes the research and development of computational skills and tools needed for Scientific applications.

The core of CS may be thought of as its collection of computational tools and methods and its problem-solving approach, which uses concepts in one discipline to solve problems in another. This CS core is now being incorporated into Computational Science courses and books that combine scientific problem solving with computation and into curricula at various levels of education.

Computational Science helps learners to solve a Physics and Mathematics problem using computer simulations and this includes diverse tasks, like:

- formulating the problem in a way suitable for simulations using models;
- choosing an efficient computational algorithm;
- running the simulations and collecting numerical data;
- analysing the data obtained;

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- extracting the solution of the problem.

According to (Landau et al., 2008) Computational Science focuses on the form of a problem to solve, with the segments that compose the solution separated according to the scientific problem–solving paradigm: i) Problem (from science), ii) Modelling (Mathematical relations between selected variables), iii) Simulation Method (time dependence of the state variables, discrete, continuous or stochastic processes like e.g. Monte Carlo simulation), iv) Development of the algorithm based on numerical analysis methods, v) Implementation of the algorithm (using Java, Mathematica, Fortran etc.) and vi) Assessment and Visualization through exploration of the results and comparison with real data received from authentic phenomena.

In Figure 1 we present the problem-solving paradigm of the Computational Science

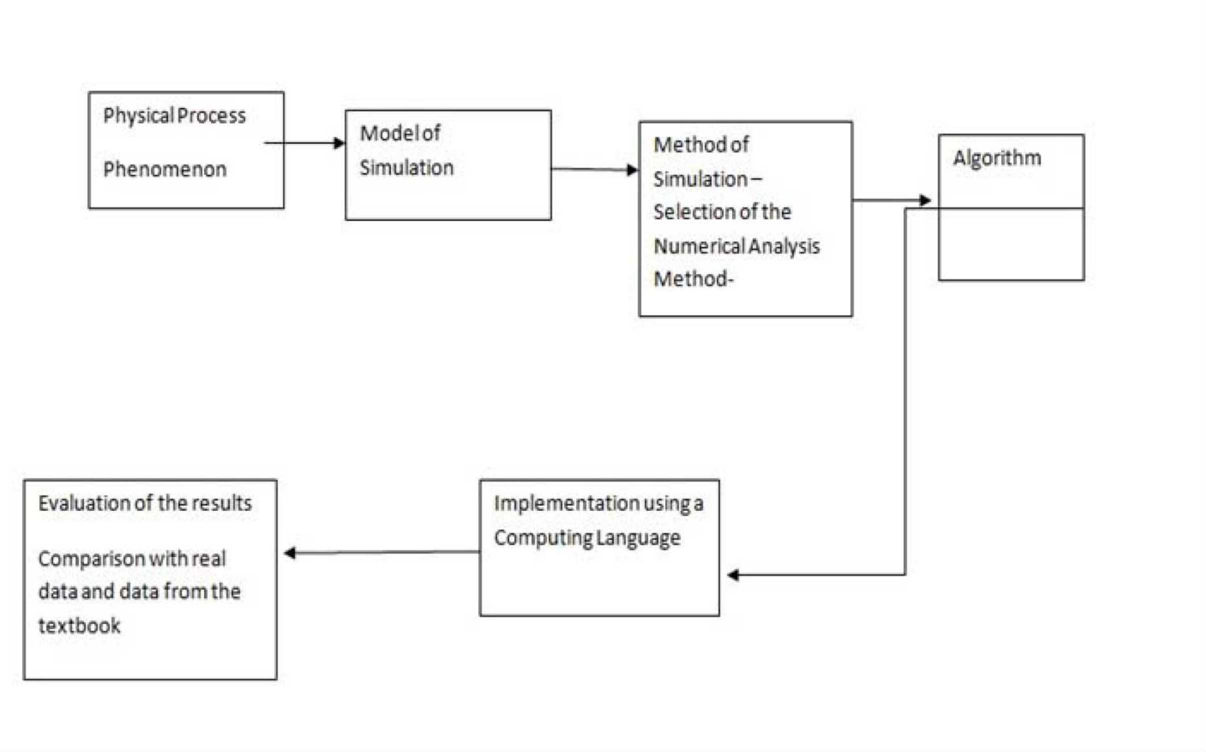

Figure 1. Problem-solving paradigm of the Computational Science

The Computational Tool

For the implementation of our theoretical approach we used software that favours the mathematical form of models.

Over the past twenty years, there has been an increasing interest aimed at developing software to support learners as they try to work in and learn using the new technologies (e.g. de Jong, Quintana et al., 2000). Even if, most of the modelling environments usually offer only one representation formalism for modelling or they are not really appropriate for young students, there is at the present a consensus for the necessity of more open and flexible learning environments and a better support of learners/students' various reasoning skills which could

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support the basic modelling characteristics in terms of variables, relation between the variables and tools for authoring.

To accomplish most of the above mentioned criteria, we used the Easy Java Simulator tool (http://fem.um.es/Ejs/, Last Access 15 July, 2015). Easy Java Simulations, also known as Ejs, is a free authoring tool written in Java that helps non-programmers create interactive simulations in Java, mainly for teaching or learning purposes. Ejs has been created as part of the Open Source Physics project (http://www.opensourcephysics.org, Last Access 15 May, 2014).

Easy Java Simulations is a software tool (java code generator) designed for the creation of discrete computer simulations including the creation of differential equation as well as more sophisticated models that include algorithms.

Ejs has been designed to let its user work at a high conceptual level, using a set of simplified tools, and concentrating most of his/her time on the scientific aspects of the "model of simulation", asking the computer to automatically perform all the other necessary but easily programming tasks.

Methodology

Participants

In this study, we report on preliminary qualitative findings from a prospective STEM course in a Greek Education Institute. Forty Five (45) Participants were prospective engineering school teachers who attend the course – EPPAIK-equivalent to Postgraduate Certificate in Education-.

The purpose of this course is-mainly to prepare students to develop pedagogical scenario that they will use models of simulations and the features of inquiry based teaching and learning approach.

Materials and Procedure

In this study we present the model of simulation to teach the motion of the pendulum integrating the Easy Java Simulation Tool and the ISE (Inspiring Science Education Tool) methodology.

At the link http://portal.opendiscoveryspace.eu/node/830849 you can find the details of the model as well the scenario developed.

For general information how to change the model you can visit the community Easy Java simulation http://portal.opendiscoveryspace.eu/community/easy-java-simulations-inquiry-based-learning-stem-disciplines-330376

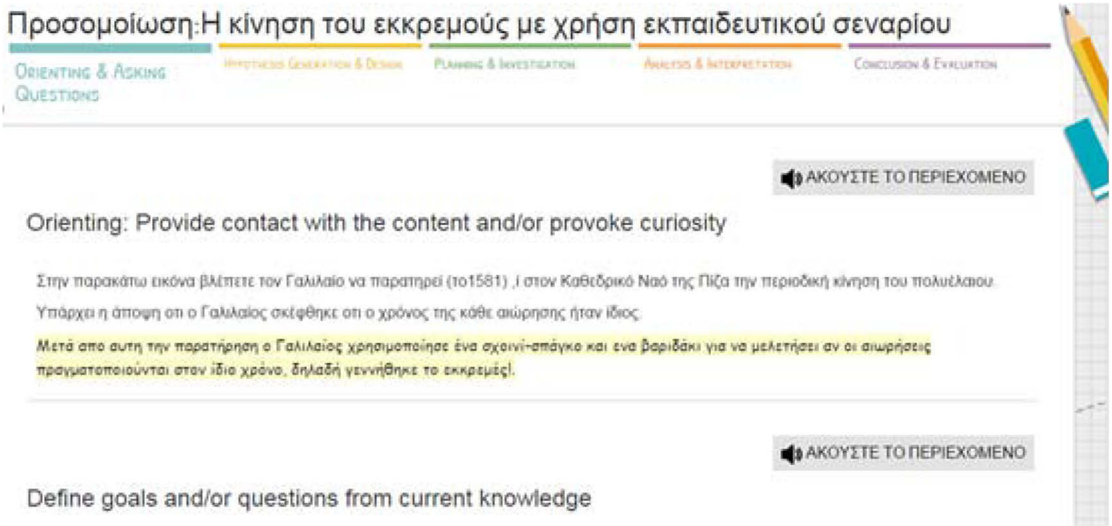

Figure 2. Snapshot of the scenario developed

At Figure 3 you can see the variables included

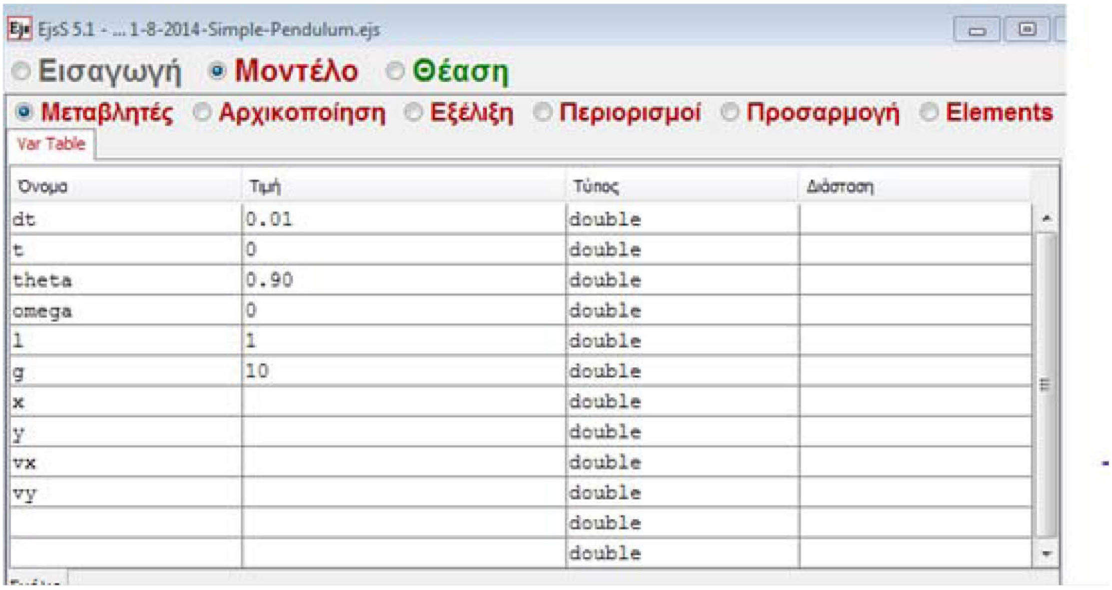

Figure 3. The variables of the model

At Figure 4 you can see the dynamical model

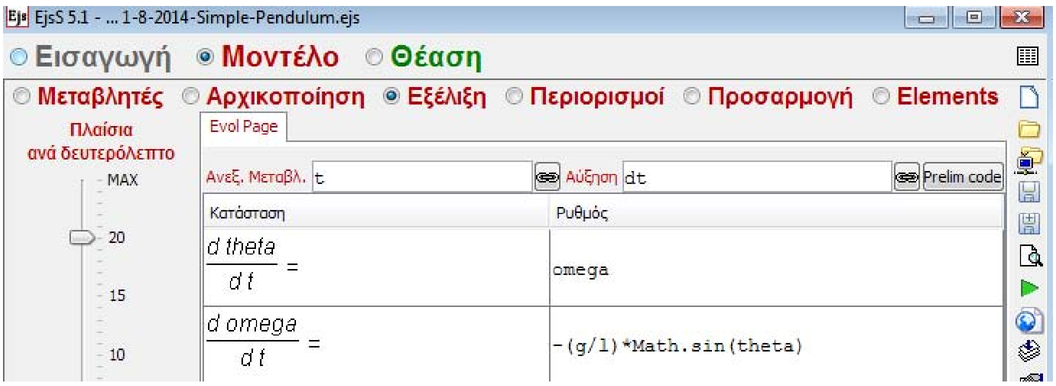

Figure 4. The dynamical equations of the model

Discussion

During the course (11 lectures) perspective engineering students discussed with the author the use of modelling indicators for different thematic areas and they were asked to recognize the modelling variables and the dynamical equations in the models developed in the repository www.opensourcephysics.org (Last Access July15, 2014). Students had the background –as graduates' engineers- to recognize the mathematical background in the models presented and they expressed the view that Ejs is a proper tool for developing models that are not "hidden" to students.

Interviews with students revealed that they believe learning should involve Problem Based Learning (PBL) or Inquiry Based Learning (IBL) tasks in Secondary and tertiary level as well as developing of models from first principles.

The interviews generally encourage students not just to report their ways of tackling their tasks, but also to reflect on their approaches in considerable depth. Analysis of the interviews follows a rigorous procedure to establish categories and the relationship between those categories, a technique which contributes to a research approach described as phenomenography.

Of course, our results are preliminary and a large scale research is prepared for the effectiveness of the tool, but we have strong indications that the integration of Ejs with ISE help to the following problem:

Curricula for Science (and STEM) Education are often criticized to be "a mile wide and an inch deep' but the growing consensus is around the need for "fewer, higher, clearer" education standards' (Schmidt, McKnight & Raizen, 1997; Xie et al., 2011). Our suggestions is based on the integration strategy that uses the methodology of the Computational experiment in deepening students' conceptual understanding through their involvement in the inquiry process, by considering the model as the fundamental 'instructional' unit and the ISE tool.

Our approach could be applicable or transferable to different STEM disciplines, and aims at aligning inquiry based learning, scientific abilities and computational thinking.

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Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

DEVELOPING A SPACEWALK SIMULATION WITH THE EASY JAVA SIMULATIONS TOOL AND IMPLEMENTING A LESSON PLAN USING THE INSPIRING SCIENCE EDUCATION AUTHORING TOOL

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Introduction

In this study, technology and tools created for educational purposes have been utilised. Initially, the application Easy Java Simulations (EJS) was used for simulating the motion model of an astronaut moving in weightlessness by means of a backpack propulsion device, like a Manned Maneuvering Unit (MMU). Moreover, a corresponding lesson plan was developed aiming at physics students or senior year school students. The covered material is based on the principle of conservation of momentum. The course was designed using the Inspiring Science Education (ISE) Authoring Tool and includes five exploratory activities. These activities use videos and other educational applications as well as the previously mentioned simulation in EJS.

This research was conducted in the Academic Year 2014-15 as a bachelor thesis for the course EPPAIK (equivalent to Postgraduate Certificate in Education) at the School of Pedagogical and Technological Education-ASPETE. This study participated at the Open Discovery Space (ODS) contest, whereas our involvement in the project and the contest enabled us to work at a high conceptual level and also contemplate other interesting simulations and educational scenarios which can be easily incorporated in our educational work.

The EJS spacewalk simulation

The scenario implemented with the EJS [1] describes the movement of an astronaut in weightlessness by means of a backpack propulsion device, like a Manned Maneuvering Unit (MMU) [2] from the left solar panel shown in Figure 1 to the right solar panel. In the following description, the names of the corresponding variables of the EJS simulation are given in the parentheses, which will be particularly useful for understanding the simulation code that can be found in [3]. The coordinates of the starting (startX = 310, 590) and termination points (endX = 700, 590) are found using the preview pane (preview) of EJS. For simplification purposes, the astronaut is moving only along the horizontal axis x.

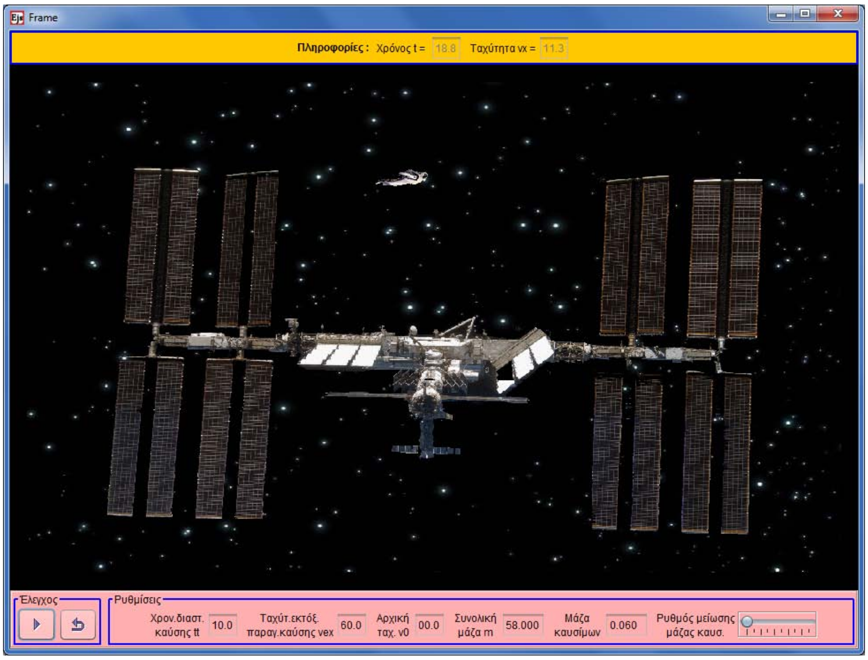

Figure 1. The main window of the EJS simulation

In order to describe the motion of the astronaut three images are used. There are boolean variables (thrust, nothrust, arrived) which determine whether an image appears or not. Specifically, as long as the MMU is operating, the first image appears (thrust = true, nothrust = arrived = false). When the fuels are over and the MMU is no longer operating the second image (nothrust = true, thrust = arrived = false) is used until the astronaut reaches his destination. Finally, when he arrives at the right solar panel and stops, the third image (arrived = true, thrust = nothrust = false) is used.

As shown in Figure 1, the main window of the simulation includes various control buttons and a multitude of labels and text fields. The user can view or define the values of the parameters of the simulation. More specifically, the upper part of the window displays information regarding the elapsed time of the simulation and the speed of the astronaut and the user cannot change these two variables. Conversely, at the bottom part of the window, there are two buttons on the left and the user can start and stop (playPauseButton) or restore the simulation to its initial state (resetButton). Additionally the user can, before the simulation starts, to define the following values: the period of operation of the MMU (tt, initial value=10 sec), the speed of the ejected derivatives of the combustion (vex, initial value=60 m/s), the initial speed of the astronaut (v0, initial value=0 m/s), the total mass of the astronaut including the MMU (m, initial value=70 kg), the mass of fuel in the MMU (mfuel , initial value=12kg) and finally the rate at which the fuel is consumed (fuelcons, initial value –dm/dt = 1,2). Especially for the consumption rate or reduction rate of the mass of the fuel a slider and not a single text field was used.

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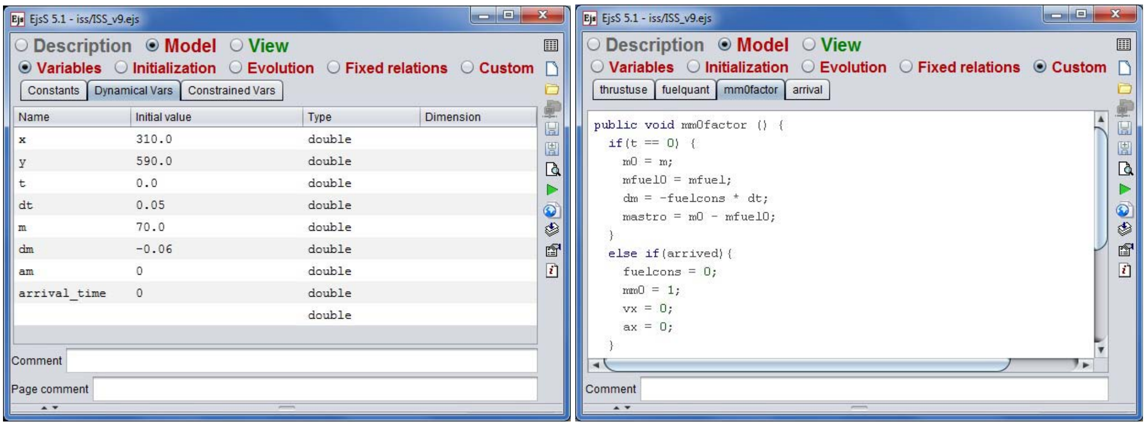

Figure 2. Indicative screenshots of the EJS model

The required variables for the implementation of this simulation are not limited to those that the user can change. There are several more intermediates. The variables were divided into categories namely into fixed (Constants tab), dynamical (Dynamical Vars tab) and constrained (Constrained Vars tab) as depicted in Figure 2. For example, the constants tab includes the variable tt (time that the MMU is in operation) and vex (the speed of the ejected derivatives of the combustion). The dynamical vars tab includes the variables x and y indicating the position of the astronaut, and the constrained vars tab includes the variable fuelcons (the rate at which the fuel is consumed).

The evolution of the simulation scenario is specified by the tab Evolution. In every step the time increases (dt), while the mass change (dm) is negative, since the mass of the system astronaut-MMU is decreasing. Finally it is worth mentioning that for the implementation of the desired functionality and graphics, some functions were created, which are shown in the Custom tab of EJS. These functions handle variable values like thrust, nothrust, arrived etc.

Furthermore, the simulation includes a separate window of graphs. The first graph represents the speed of the astronaut at any time and the other the corresponding acceleration, as shown in Figure 3.

By assigning different initial values to the variables and executing the simulation, the students can draw their conclusions about their effect on the model. This is very useful in the third phase of the ISE lesson, where the students are required to conduct some research on the topic.

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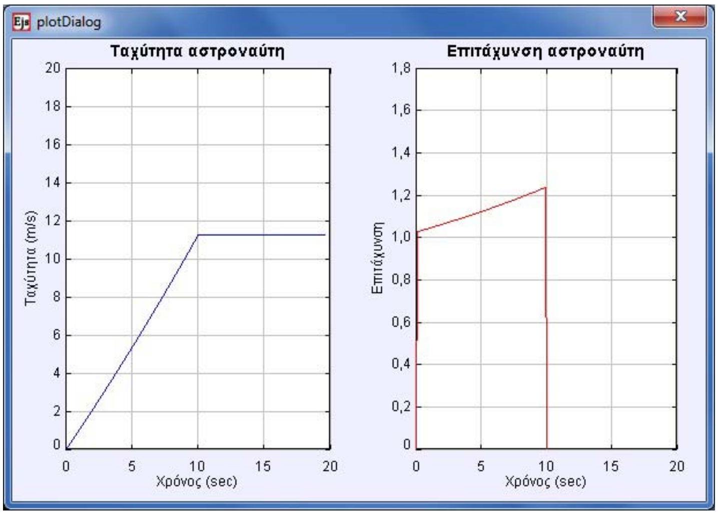

Figure 3. Graph window of the EJS simulation

Lesson designed using the ISE Authoring Tool

The purpose of the ISE (Inspiring Science Education Tool) Authoring Tool is to provide digital resources and opportunities for teachers to make science education more attractive and relevant to the students' lives. Through the website of ISE and the activities organized by the participants, teachers can help students make their own scientific discoveries, to witness and understand natural and scientific phenomena and have access to interactive tools and digital resources through their class.

The ISE Authoring Tool is a tool for developing a lesson plan with specific, guided steps. Each lesson (Lesson Plan) consists of five phases (inquiry activities), including fields that must be completed.

1. Orienting and Asking Questions
2. Hypothesis Generation and Design
3. Planning and Investigation
4. Analysis and Interpretation
5. Conclusion and Evaluation

The corresponding lesson plan was developed aiming physics students or senior year school students regarding the course of Physics. The material covered is based on the principle of conservation of momentum. The educational scenario developed is available in [4].

Orienting and Asking Questions

This particular phase consists of three components: a) Orientation: The teacher is providing an initial approach to the material covered and / or challenges students' curiosity. The research process can focus on answering a question, but also on other objectives such as exploring a controversial dilemma or solving a problem. The teacher can support the whole process using examples, stories, videos, or simulations. Students can take notes, ask questions and discuss the content. b) Define the objectives and / or questions from the current knowledge: It is necessary to clarify the objectives to be achieved. The aim of the scenario can be phrased as a question or problem that occurs during the first contact with the content. c) Exploring and Understanding: The students must answer several questions in order to describe the phenomenon they observed and also to understand how information from various sources is related.

In our lesson plan, the students must watch a video from the movie "Gravity" in order to get a first idea on the content and/or provoke curiosity (Orientation). Subsequently, the purpose of the lesson plan is formulated through questions that the students must try to answer (Define the objectives). The questions are relevant to the video they previously watched. The possible answers are also cited (Exploring and Understanding). In Figure 4 a snapshot containing a part of the Orienting and Asking Questions phase is shown.

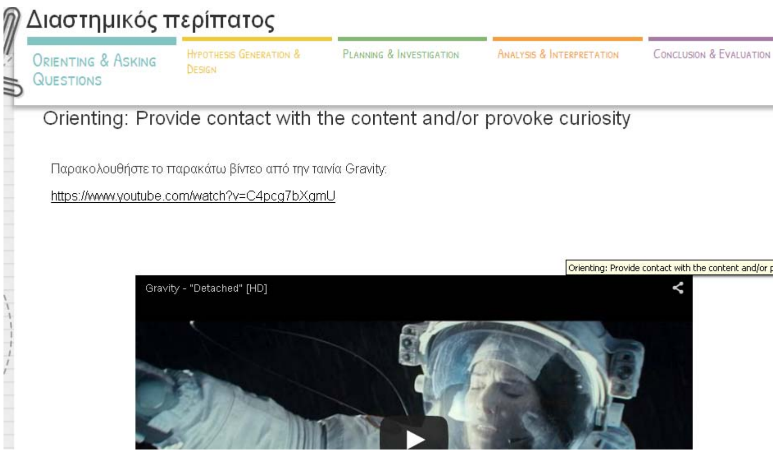

Figure 4. Orienting and asking questions

Hypothesis Generation and Design

This particular phase consists of three components: i) Hypothesis generation and preliminary explanations: Along with the prior knowledge of students and the notes taken, the structure of the problem is the basis for the formulation of a hypothesis that describes possible relations between measurable dependent and independent variables. As a result the students create assumptions based on a question or problem. ii) Design a model: Another approach to the investigation of cases is to design a model. iii) Representation and Configuration: The students must be encouraged to answer several questions and also try different forms of representation, for example they can try to transform the format of information to another format in order to better understand the problem.

In this specific educational scenario, the students must exclude some preliminary explanations regarding how an astronaut can move in space (Hypothesis generation and preliminary explanations). The problem is compared to the case of a spacecraft. As the fuel of the rocket is thrown backwards the spacecraft is pushed forward. Then, the spacecraft constantly accelerates and reaches a certain speed. When the fuel is over, no force is applied to the spacecraft (provided that the spacecraft is far away from planets). The students are

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encouraged to "play" with the application which can be found at [5] in order to understand how the spacecraft can move using a fuel propulsion device (Design a model). Finally the students must try to answer some questions (Representation and Configuration). In Figure 5 a snapshot containing a part of the Hypothesis Generation and Design phase is shown.

Figure 5. Hypothesis Generation and Design

Planning and Investigation

This phase consists of three components: i) Design Research: The clearly formulated hypotheses facilitate the planning of the work process. The design includes the determination of the order of activities and milestones, what tools and/or data will be used, a clear timeline, and how these activities can be divided among the participants. ii) Conduct Research: In this activity students can gather data from: experiments, literature survey, surveys etc. iii) Design and Implementation: The students must try to find a solution to the observed problem.

Our educational scenario incorporates the EJS simulation developed by the authors and described in section 1. More specifically, the students should modify the parameters in the above simulation and try to answer questions, such as: what kind of movement the astronaut makes as the fuel burn, by observing the diagram window, which parameter changes when the fuel is over, what is the relation between the motion of the astronaut and the fuel consumption rate (Design Research). Furthermore, instructions are provided to the students in order to investigate certain problems and experiments that are related to the principle of conservation of momentum such as missile launch and the motion of a man on top of a frozen lake where the surface is approximately smooth and the friction is practically zero. The students must then search for similarities and differences between the application of the principle of conservation of momentum in the two above cases and the motion of the astronaut as described in our simulation (Conduct Research). Subsequently the students must try to answer some questions (Design and Implementation). In Figure 6 a snapshot containing a part of the Planning and Investigation phase is shown.

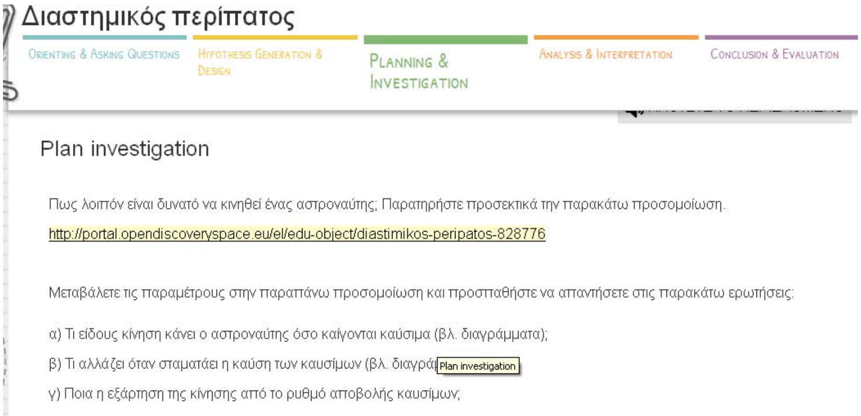

Figure 6. Planning and Investigation

Analysis and Interpretation

This phase consists of three components: i) Analysis and Interpretation: After collecting the data from the investigation on the previous phase, the data must be processed for reading the information out of it. ii) Monitoring and Reflection: Several questions are set in order to stimulate students to think creatively. Moreover, the students should review their results under different aspects.

In this section the students must come to conclusions from the data that they retrieved from the EJS simulation during the phase "Planning and Investigation" (Analysis and Interpretation). The graph window will help the students answer the questions that describe the way the astronaut is moving in weightlessness by means of a backpack propulsion device (Monitoring and Reflection). In Figure 7 a snapshot containing a part of the Analysis and Interpretation phase is shown.

Conclusion and Evaluation

In this section the conclusions are specified alongside with a presentation of the results and the interpretations. The evaluation process can be facilitated by presenting conclusions and results to a broader audience. The students can use common presentation tools like power point but also online tools for sharing results with students of other classes or other schools.

Figure 7. Analysis and Interpretation

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Discussion

In this paper, a simulation of the motion model of an astronaut in weightlessness by means of a backpack propulsion device was presented. The simulation was created using the Easy Java Simulations (EJS) tool and it is now a resource in the "Easy Java Simulations for Inquiry Based Learning in STEM Disciplines" community of the Open Discovery Space (ODS). More specifically, it is entitled as "Space Walk" and it is available for use for teachers, students and pupils [3].

Also a lesson plan was developed aiming physics students or senior year school students. The material covered contains subjects as accelerated motion and conservation of momentum. The lesson plan was created using the ISE (Inspiring Science Education) Authoring Tool. This course is based on the above simulation. This resource is also a resource of the same community and it is available at [4].

The EJS simulation and the ISE lesson plan help students to be more creative and to discover knowledge on their own using the simulation and also searching various sources and literature. As a result, they understand the subject more efficiently and gain motivation to broaden their knowledge in a very interesting manner. In other words, the exploitation of the EJS simulation in combination with the five directed phases of the ISE Authorig Tool, enable the students to discover knowledge by themselves. This is particularly significant in the absorption and the long term retention of knowledge by the students.

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

ENVIRONMENTAL EDUCATION THROUGH ENQUIRY AND TECHNOLOGY: THE CASE OF THE GREENET PROJECT

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Summary

Green education has been significantly benefited over the last years from the developments of EU-funded projects; from the Organic.Edunet Web portal (www.organic-edunet.eu) with more than 12,000 quality educational resources from various content providers and the extensive, even though more generic, repository of the Open Discovery Space (ODS; www.opendiscoveryspace.eu) project and the thematic one of the Natural Europe (http://www.natural-europe.eu) ICT-PSP project, the scientific community developed in the context of the Open Science Resources (OSR; http://www.ea.gr/ep/osr) and the contribution of the Organic.Lingua ICT-PSP project (http//www.organic-lingua.eu) in terms of increasing the multilinguality features of both the content and the repository hosting it. These projects, as well as numerous additional ones, have worked on the aggregation and facilitation of sharing and use of quality educational content covering a wide variety of green topics.

However, over the last years it became obvious that there is a clear need for defining a methodology and the means for serving different learning communities with content from the aforementioned pools (as well as additional ones) that will meet their different and specific educational and learning needs. This would have to be channelled through the development and use of these tools that will enhance search, retrieval and reuse of high quality content already available through any educational repository or other source of educational resources. In this context, the GreeNET project (http://greenet.ea.gr) has developed a set of tools as well as the corresponding best practices that aim to support education on green topics by providing value added services and enhancing the retrieval, sharing and use of high quality educational resources. The aim of this paper is to provide a brief description of these tools, focusing on the opportunities that they offer to their potential end users.

Introduction

Education is a field of major importance for the progress and evolution of communities; at the same time it is a field going through constant and important changes throughout the years. Moving from the traditional model of a teacher delivering courses in a classroom using blackboards and hand-written notes, modern educational systems have integrated new approaches, such as blended learning, distance learning, use of open educational resources (OERs), learning portals, digital repositories and learning management systems, to name a few. As a result, teachers and other types of educators need to be constantly updated on the advances related to the educational systems so that they can actually make use of them and improve their way of teaching. Through their engagement in communities, teachers are able to exchange ideas and best practices on their field of expertise.

Green education has been one of the most active educational fields over the last years, due to the increased environmental awareness of a wide variety of stakeholders. Following the evolution of the general educational systems, it has successfully integrated a number of modern approaches and tools such as digital repositories and learning portals offering access to green OER (such as the Organic.Edunet Web portal; www.organic-edunet.eu), communities of educators on green topics, delivery of online courses etc. The GreeNET project (http://greenet.ea.gr) has identified the specific needs of communities of green educators, which were focused on the retrieval of best practices on green educational topics, the authoring of such best practices and the delivery of online courses which made use of such best practices as well as of content already available through quality repositories. The project aims at setting up and maintaining the GreeNET Inventory and Community Building as well as related adaptable mechanisms that will enable access to all interested parties to find, exchange and adapt digital resources and discuss ideas and best practices on 'green living and teaching'.

In order to provide useful services to its potential end users, the project will work towards the following objectives:

- Analyze alternatives for integrating best practices and associated descriptive information (metadata);
- Integrate best practice resources of all forms (such as learning content of a best practice and assessment resources used to assess the practice);
- Collect actual usage and other social information on used best practices by users and use the collected data for enhanced filtering and recommendation of relevant practices.

Taking these into consideration, the GreeNET project has developed the following three tools in order to meet the needs of the communities studied:

- The GreeNET Inventory;
- The Best Practice Authoring Tool;
- The GreeNET Moodle instance.

These three tools will be described in the following sections.

The GreeNET Inventory

The GreeNET Inventory (http://greenet.spg.latramis.com) is a Drupal-based tool that allows the collection and retrieval, among others, of Best Practices. Through its modular approach, the GreeNET Inventory allows users to find quality OER on green topics, to learn how to

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author Best Practices, to engage participants of events in interactive activities and even to create their own portal with green OER from selected external sources. The Best Practices available through the GreeNET Inventory are provided by GreeNET project partners as well as from affiliated institutions in the areas of environmental education and green jobs counselling.

Figure 1. The homepage of the GreeNET Inventory

The home page of the GreeNET inventory proposes a workflow/framework on how the existing GreeNET tools can be used by the end users. More specifically, the GreeNET Inventory allows users to:

a) Search for online resources in green issues

This option helps users identify green Open Educational Resources (OERs) of interest from the GreeNET OER Finder (http://greenet.spg.latramis.com/discovery). This finder currently provides access to almost 4,000 resources that can be filtered by collection, language of the resource, educational context, resource type and expected end user role. These resources are described with metadata based on the widely used IEEE LOM standard for educational resources, a fact that enhances the interoperability of the finder with related external systems and at the same time increase the search capabilities of the discovery space.

This discovery space provides access to green OER in thirteen (13) different languages from seven (7) different collections so far; one of these being the green collection of the ODS project, through an ongoing interconnection of the repository. These resources are appropriate for various educational contexts but always focusing at school level, aiming at teachers, learners and other types of educators. The resources are of different types, such as lesson plans, enquiry-oriented activities, best practices, prototypes and pathways, among others, also including various types of multimedia files (such as videos and presentations).

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b) Get inspiring ideas through the organization of creative activities in their schools

In this section (http://greenet.spg.latramis.com/node/6), users are introduced to the concept of the Green Ideas events, which are interactive and engaging workshops that explore ways in which green innovation may be empowered by education and technology. These events are organized in the form of dynamic workshops that use the design-thinking approach to innovate new ideas with actionable next steps.

c) Get guidance through the authoring process of best practices for the classroom

This option (http://greenet.spg.latramis.com/node/7) allows users of the GreeNET community to receive more information on the design of educational activities based on Best Practices. In this section, users are provided with a checklist that allows them to check how compliant their activity is with the concept of Best Practices and on top of that to access the manual of the Best Practice Authoring Tool.

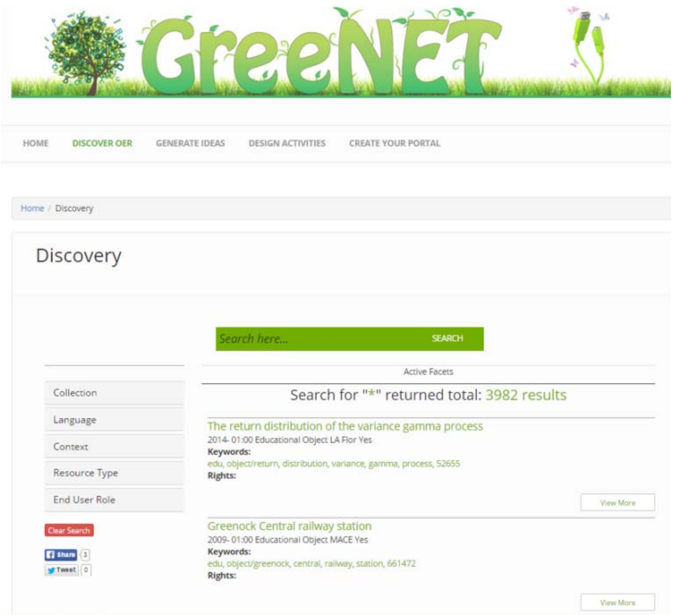

Figure 2. The GreeNET OER Finder

d) Create their own school portal on green ideas and projects sharing locally or in public the outcomes of their work (http://greenet.spg.latramis.com/node/5)

Through the use of the School Portal Generator (SPG – http://spg.latramis.com), users are allowed to create portals that provide access to selected green OER, based on user-defined filters. A video tutorial on the use of the School Portal Generator is available through YouTube (https://www.youtube.com/watch?v=Ppo0luWBjM8).

The GreeNET Inventory is also used as the school community hub of the Green Learning Network (GLN; http://www.greenlearningnetwork.eu) project. More specifically, in the context of GLN a number of social features have been added, allowing the community to share material through social media, including Facebook and Twitter. This is based on the fact that an increased number of educators use social media not only for personal purposes but for professional as well; thus, the option to enable sharing of quality educational content through social media with other colleagues is expected to increase access to and usage of this material among different but connected communities of educators. The combined communities will increase the impact of the solutions proposed by the GreeNET project among various communities of teachers while at the same time, there will be an exchange of information, knowledge and experiences between different but interconnected user communities.

The GreeNET Best Practice Authoring Tool

In order to help green educators design and create innovative Best Practices, an online software tool that guides them through each step of the best practice design has been developed by the project. In this context, the Best Practice Authoring Tool (http://greenet.spg.latramis.com/node/7) provides the user environment for creating these Best Practices and at the same time a digital repository of educational scenarios and digital resources.

The resources created and stored in the authoring tool can be easily searched, retrieved and used into a new or existing best practice. In addition, authors using of the Best Practice Authoring Tool are allowed to upload and store their own resources to be used in their Best practices. Apart from that, the tool allows users (but not authors) to search for and use educational scenarios as well as to play with digital resources.

Figure 3. A Best Practice uploaded in the GreeNET Best Practice Authoring Tool

All best practices created with the use of the GreeNET Best Practice Authoring Tool are described with educational metadata based on the IEEE Standard for Learning Object Metadata (LOM – https://standards.ieee.org/findstds/standard/1484.12.1-2002.html), in order to facilitate their management and interoperability with external content management systems (such as digital repositories, metadata aggregators and web portals, among others).

The GreeNET Moodle

The GreeNET Moodle (http://greenet.eummena.org) instance allows users, such as teachers and other educators, to access all best practices and OER that are available through the GreeNET Inventory described earlier. This integration of the GreeNET Inventory content allows teachers to access the GreeNET learning resources and activities from within Moodle. On top of that, the connection of the GreeNET Moodle with the Open Discovery Space (ODS) repository allows the GreeNET Moodle users to have access to the massive number of relevant learning resources of ODS without leaving the GreeNET Moodle environment. All these resources from the two aforementioned repositories (GreeNET and ODS respectively) allow the Moodle users to enrich their courses with high quality content, which can be used as supporting material of a course.

Figure 4. The homepage of the GreeNET Moodle

The GreeNET Moodle instance comes with a number of collaboration plugins preinstalled, in order to enhance the collaboration between different educators, as well as a green theme to match the concept of the green topics discussed in the courses.

Conclusions

In a time where teachers and other educators have access to a wealth of quality educational resources, digital repositories, web portals and other sources of quality content for their courses, the need for customized tools that will allow the refinement of content search, retrieval and use became obvious. Teachers need to have access to customized and adaptable tools that allow them to access and make the best use of the available quality content, so that they can integrate it in their teaching activities. At the same time, it is of high importance to allow the recording, sharing and use of best practices already in place by green educators so that this knowledge will be available to be reused in different contexts.

The tools described in this paper aim to support teachers and educators in creating, storing, indexing and retrieving quality educational resources in the form of Best Practices, OER and courses. The GreeNET inventory provides users with a number of options that aim to boost the creativity of teachers and other types of educators, by introducing them to the concepts of Best Practice-based interactive activities and the Green Ideas series of events. It also provides

ISBN 978-615-5511-06-6

all the necessary information to everyone wishing to author Best Practices or retrieve quality green OER from the GreeNET discovery space. The Best Practice Authoring Tool allows its users to create Best Practices through an easy to use interface, making use of existing green OER available through the GreeNET discovery space (a part of the GreeNET inventory) or through other sources of quality OER. Last but not least, the GreeNET Moodle instance allows users to develop courses and make them available to their students, using the high quality OER and Best Practices available through the GreeNET Inventory and the ODS repository as essential parts of their courses.

It is important to mention that in order to ensure the interoperability between the different systems and ensure their wide application, all these tools are based on widely used open source platforms. More specifically, the GreenNET Inventory has been built on the open source Drupal platform (https://www.drupal.org), one of the most widely used content management platforms. Drupal is supported by a large user community, including developers, system administrators and content experts and supports a large number of interoperability and extensibility options.

The Best Practice Authoring Tool is based on the widely used, open source Omeka platform (http://omeka.org), which has already been used in other instances for serving different types of applications. Examples of these applications are the Agricultural Learning Repository Tool (AgLR), which has been developed and used by the Organic.Lingua project as its main repository and metadata authoring tool and the Pathway Authoring Tool of the Natural Europe project.

The GreeNET Moodle instance is based on the Moodle platform (https://moodle.org), a widely used learning platform designed to provide educators, administrators and learners with a single robust, secure and integrated system to create personalised learning environments. Moodle is also supported by an ever-growing user community and supports various interoperability and customization options.

The use of open source tools and platforms provides a number of advantages over commercial software and ensures, among others, constant support from the user community, access to various customization options, use of existing standard file formats (avoiding proprietary ones) as well as minimum (or even) no cost for related to licensing.

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Acknowledgements

The work of all authors has been funded with the support of the European Union Framework of the Lifelong Learning Programme under grant agreement no.527891 in the context of the “GreeNET: Environmental Education through Enquiry and Technology” project. This work has also been partially supported by the Green Learning Network LLP-KA3 project and the Open Discovery Space ICT-PSP project. This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

GREENET: SUPPORTING GREEN CAREERS THROUGH EFFECTIVE EDUCATIONAL INITIATIVES

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Abstract

Future generations need to acquire sufficient know-how to effectively address environmental issues. The GreeNET project, responding to this need, provides effective inquiry-based driven Best Practices in order to support teachers for effective preparation of students of all ages to balance a sustainable future. In this move, the GreeNET network builds upon existing EU Best Practices to develop skills which are necessary for the green jobs market. Overall, this move is supposed to further overcome the apparent gap in green initiatives to various school science subjects in supporting future career path choices.

Relevance of Best Practices

As a result of the current global change, our society needs to follow new ways of thinking by developing key competences necessary, for instance, to increase awareness for environment and sustainable living. The EU community considers education as most prominent instrument to intervene with human attitudes and behaviour towards more environmentally sustainable patterns (Bogner, 1998; Nicolae, 2005). A major role for this play specially trained teachers (Stokes et al., 2001), who as properly trained experts effectively carry out educational multiplication, for instance, to increase expertise and ensure sustainability. Within this context, the ROCARD-report (2007) regards teachers as "key players … being part of a network allows them to improve the quality of their teaching and support their motivation".

The daily experience still shows a lack of concrete policy for advancing strategic skills that correspond to the identified need for the connection of environmental education to the green labour market (European Centre for the Development of Vocational Training, 2010). Therefore, specific programmes such as GreeNET correspond to this increasing recognition, through the development of a network that is going to strengthen the connection between environmental sciences education and the respective labour market. Promoting innovative and engaging activities that project the scientific aspect of environmental education, GreeNET aspires to provoke interest on green sciences among students, and thus contribute to the increase of number of students choosing science-related subjects.

Naturally, some of such innovative educational activities already may exist but they maybe are exceptions and do not communicate with each other. The GreeNET goal is to develop an appropriate scheme for collecting and exchanging these exceptional good practices and their respective tools in the area of environmental education and green careers counselling that exist in various EU countries. This way, GreeNET network addresses the necessity to develop an integrative approach in collecting and disseminating Best Practices that promote environmental education using inquiry-based and problem-solving approaches. Against this background the collected Best Practices function as methods that have "consistently shown results superior to those achieved with other means, and which are used as a benchmark to strive for" (Burkhart, 2010).

Framework

Identifying Best Practices most suitable to the project's purposes a systematic methodology to define the criteria and rules must had been developed. Consequently, in a first step towards the collection of educational Best Practices, the main aspects of the Best Practices content and goals were defined and thoroughly explained. This step was based on an extensive literature review. The elaborated main components of the GreeNET project, which are to be explained in this chapter, are:

- Education for Sustainable Development;
- Inquiry-Based Learning;
- Green Labour Market;
- Use of ICT-Tools.

Educational Initiatives

Around the world, a general awareness is growing that we live together on a planet with limited resources (Herbert, 2008). This requires new ways of thinking and calls for support to key competences necessary for active citizenship and social cohesion, as well as a turn towards green professions (Orr, 1992). Since some decades, the Environmental Education has been considered as the most appropriate medium to address these needs, due to its matching goals and objectives. The goals and principles of Environmental Education are declared in the Belgrade charter and are implemented almost all education programmes. It is important to focus on the objectives awareness, knowledge, attitude, skills, evaluation ability and participation as part of the programmes (UNESCO-UNEP, 1976).

The implementation of appropriate programmes and activities with these mentioned objectives is one task school teachers and environmental educators have to challenge with. In order to facilitate teachers to implement innovative methods teaching complex environmental issues, and introducing students to nature and science in a new way, GreeNET will disseminate effective inquiry-based Best Practices. Furthermore, it will significantly contribute to elevate the number of sensitized citizens who support sustainable development through everyday actions. This will effectively address the European Commission's High Level Expert Group on Science Education Renewal argument that "articulation between national activities and those funded at the European level must be improved" (Rocard, 2007). Therefore, students' work on an environmental issue should include identifying, exposing and analysing the conflicting interests and how they affect our future. At the same time, it is important to improve action competence of students as one of our main goals for the new generations of environmental education (Breiting & Mogensen, 1999).

Understanding green issues is essential for and in today's society. The public's comprehension is largely dependent of knowledge of science and is therefore influenced by classroom experiences in science classes. In consequence, it is important that science teachers understand and acknowledge 'green science' and provide accurate teaching approaches. Science is defined as a body of knowledge, a process of inquiry, and the people involved in the scientific enterprise. Students should understand the process of scientific inquiry as well. In this context, inquiry may be considered as "the intentional process of diagnosing problems, critiquing experiments, and distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments" (Linn, Davis & Bell, 2004).

Green Labour Market

GreeNET is specifically related to the 'green labour market' because the project focuses on an effective and lasting connection of Environmental Education to green career choices. This labour market sector includes 'green jobs' that UNEP defined "as work in agricultural, manufacturing, research and development, administrative, and service activities that contribute substantially to preserving or restoring environmental quality. Specifically, but not exclusively, this includes jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high efficiency strategies; de-carbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution" (Renner, Sweeney & Kubit, 2008). These jobs are definitely necessary in a green economy that "does not generate pollution or waste and is hyper-efficient in its use of energy, water, and materials" (Renner, Sweeney & Kubit, 2008).

The issue identified is that students often do not have an insight in green careers. Moreover, teachers widely connect green jobs to blue-collar jobs, seen from environmental point of view. Of course, green jobs do not only regard the hands-on career choices, but also include these professions that require high academic knowledge. Therefore the Best Practices should demonstrate concrete professions of sustainable economy. The implementation of this aspect should be demonstrated by Best Practices so that students get in touch with a variation of green careers. Thereby, the benefit of sustainable behaviour in our society will be made obvious for the students and support them in their decision concerning green careers.

Use of ICT-Tools

During the last decades, the use of information and communication technology (ICT) rapidly increased in modern society. "One of the basic requirements of education for the future is to prepare learners for participation in an information society in which knowledge is the most critical resource for social and economic development and where distributed expertise and networked activities characterize the emerging types of work" (Hakkarainen et al., 2000).

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E-learning as part of that quickly evolving society characterizes current and future educational systems, fulfilling the requirements for learning in that modern domain (Sun et al., 2008).

ELearning is generally defined as "all forms of electronic supported learning and teaching, which are procedural in character and aim to effect the construction of knowledge with reference to individual experience, practice and knowledge of the learner. Information and communication systems, whether networked or not, serve as specific media to implement the learning process (Tavangarian, Leypold, Nölting & Röser, 2004). Using ICT-Tools requires a change in prevalent teaching style, in learning approaches and in access to information. It is the central objective to lead instructors and learners not to be discouraged by that change, but rather to see it as a great opportunity (Watson, 2001). For that reason the use of ICT-tools became one important aspect in the GreeNET project.

Underlying Criteria and Rules

As a result of the literature review about the main components of the project a guideline with essential criteria was elaborated to ensure the quality of GreeNET's Best Practices.

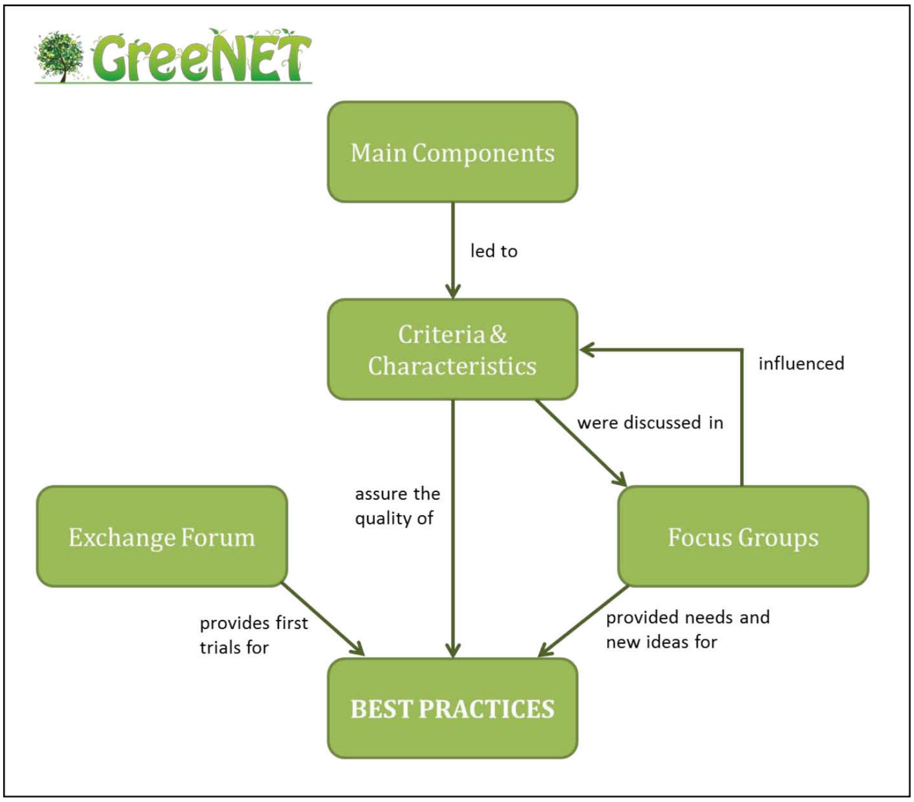

Figure 1. Development Process of GreeNET's Best Practice

To shed more light to the current situation a number of focus groups in all participating countries was carried out. The focus group led to the analysis of the needs and problems of teachers and environmental educator. The outcome influenced the content and methodology of the Best Practice collection. Furthermore the already elaborated criteria of GreeNET's Best Practices were discussed and evaluated by the focus group participants. The results of that

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evaluation were ten essential criteria to assure the quality of the Best Practices, including one merged and two new criteria.

In addition to focus groups, a Best Practice Exchange Forum was carried out as a large scale event, offering European teachers the opportunity to interact, discuss and compare educational content regarding environmental education and inquiry-based learning. The result of that event was amongst others 17 elaborated scenarios following the inquiry approach with a green topic. Four outstanding good practices of these scenarios can be selected for GreeNET's Best Practice collection. All in all, 26 Best Practices were collected by all participating institutions, following the elaborated criteria.

Table 1: Ten essential criteria of the Best Practices

Criteria and Rules
1. Relation to a green topic and curriculum
2. Being interdisciplinary: Drawing upon many academic disciplines and teaching methods
3. Relevance to the daily life of students
4. Based on accurate and factual professional expertise
5. Connection to professions in the green labour market
6. Learning by research and inquiry
7. Activation of the students by hands-on
8. Enhancement of students' ICT skills
9. Support of the development of social skills
10. Adaptability of the programme

HOBOS as outstanding Best Practice

To show exemplarily an Best Practice, "HOBOS – To Bee or not to Bee" is presented in more detail, a learning programme for secondary schools about honeybees using the interactive online learning platform HOBOS (HOneyBee Online Studies). HOBOS allows all forms of investigation: A short visit to the honeybee colony with technical equipment like webcams, sensors, endoscopes and thermos-vision provides (virtual) access to a bee colony around the clock. These data, together with data on the weather and vegetation (like measurement of the water demand of the plants) not only are presented live, but can be used offline as well. HOBOS also allows for ambitious long-term projects, which support independent work and inquiry-based learning.

The "To Bee or not to Bee" programme is structured in a learning cycle including four interdisciplinary topics. Each topic contains two working stations with analogue and digital content (see Figure 2). To solve the eLearning-exercises the students use different tools and data from the internet platform HOBOS. The topics do not build upon each other, they could be considered as independent learning modules. The overall aim of the programme is to promote appreciation of students for honeybees as necessary organism for environment.

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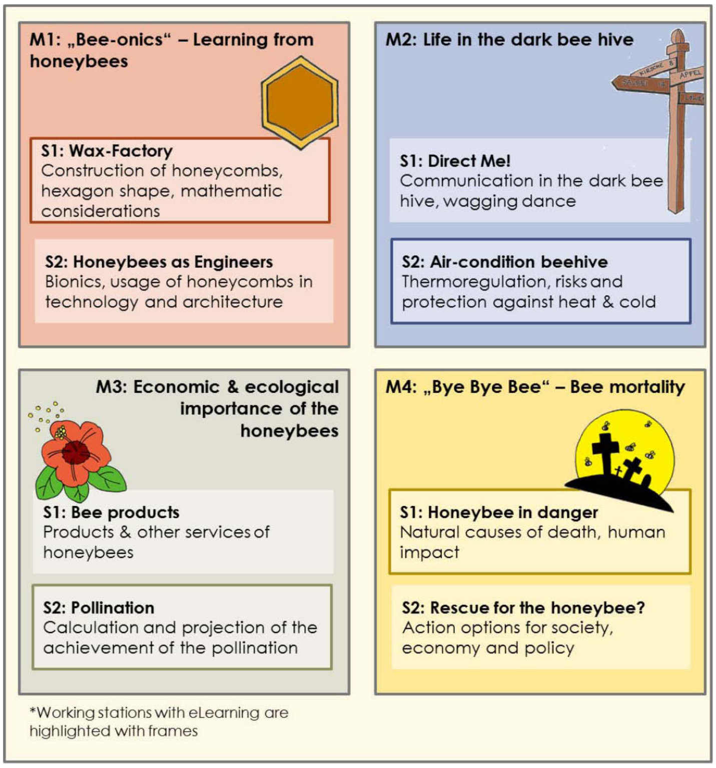

Figure 2. Design of the learning cycle "HOBOS – To Bee or not to Bee"

The educational content of the learning programme was compiled by the University of Bayreuth using new designed material supplemented with already existing HOBOS material as well as ideas from the GreeNET Best Practice Exchange Forum with international participants.

The learning programme was implemented with approximately 200 Bavarian secondary school students and empirically monitored concerning cognitive and affective achievement. For instance, due to the HOBOS programme the participating students gained significant (all $p<0.00$) new knowledge in short- and middle-term (see Figure 3; error bars represent 95% confidence interval).

ISBN 978-615-5511-06-6

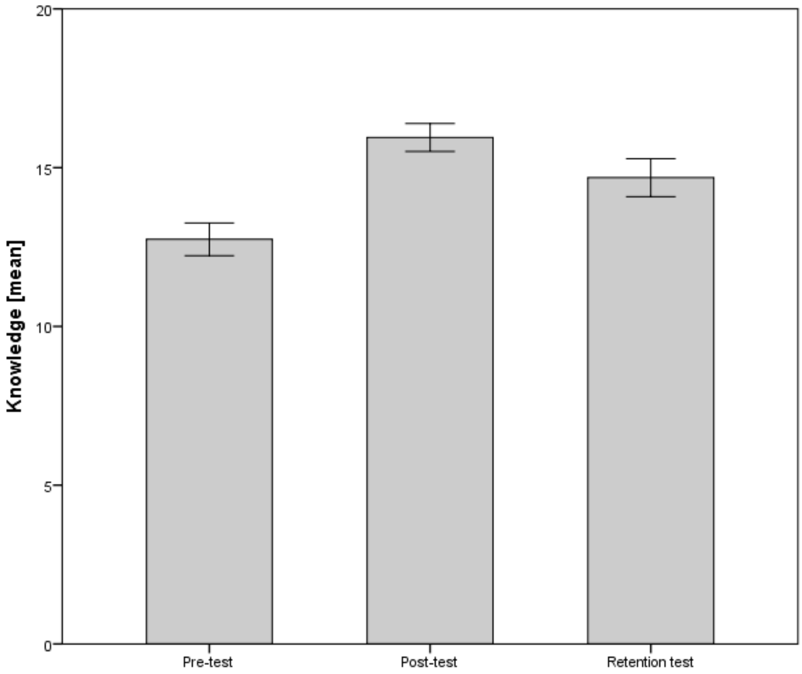

Figure 3. Effect of learning programme on students' knowledge level.

Beside the implementation of the programme by itself we focused on dissemination and evaluation of HOBOS. Professional developments with regional teachers as well as various training modules with pre-service teachers support the use of the programme in future and provided positive feedback about the applicability of the educational content.

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

EVALUATION OF ACTIVITIES IN THE NETWORK "GREENET"

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Background the Styrian Association for Education and Economics and the motives to be partner in GreeNET

The Styrian Association for Education and Economics (STVG) is a non-government not-for-profit organization working in the area of education, world of work and labour market since 1955. Since more than twenty years STVG is active in European cooperation, projects and networks, in LLL-Programme Comenius, Leonardo, Grundtvig, Joint actions as well as in seventh framework programme. STVG cooperates with partners in governments, social partners, science and research all over Europe.

STVG is specialised in seminars and trainings for apprentices, students and adults, career guidance and counselling, entrepreneurship education for young people but also for teachers training.

The interest of STVG for joining this network was based on the connection between school and the world of work which was also the main topic of two large projects coordinated by STVG: School & WOW (http://www.school-wow.net) and EE & WOW (http://www.ee-wow.net). Both Topics: the communication, cooperation and coordination of activities to foster the dialogue between schools and the world of work (WOW) as well as entrepreneurship education and the world of work supports young people to find a smooth transition from school to the labour market.

Green jobs are one of the most prosperous professions in the future. But in the same time environmental education supports young people to find a proper way for their own environment, personal life and foster their responsibility for save their own environment – a "green thinking". These topics in combination with the main aims of STVG were the prior interest of STVG to be partner in the network of GreeNET.

Evaluation and Quality Assurance within GreeNET

Within the network GreeNET the partner Styrian Association for Education and Economics (STVG) is responsible for work package 5 "Evaluation and Quality Assurance".

Within this task following elements were evaluated regarding the quality assurance:

- The effective process (communication and progress, meetings of the consortium);
- Process of the project (events / products / outcomes of GreeNET).

The evaluation of the Network was mainly focussing on the 2 implementation phases A and B in the last 2 years and on the impact of these 2 phases for the best practises for environmental education on the one hand and on the validation phase on the other hand. This paper will give a compact overview about the evaluation of the best practises from users in the 1st and 2nd circle as well as a short overview about the evaluation methods in the validation phase.

Practises of Environmental Education: but what are Best Practises? The Evaluation Approach

Within two phases of implementation (phase A and B) the practises for "Environmental Education through Enquiry and Technology" were disseminated to teachers and trainers. Within the network activities of GreeNET best practices were collected during the first phase of activities in the partner countries. They are summarized within the deliverable D 2.5 "Best Practices of Enquiry-based Environmental Education and Training Methods" collected by Mona Schönfelder and Prof. Franz X. Bogner both from the University of Bayreuth, Department of Biology Education.

Based on the indicators for the description of the best practises the evaluation questionnaire for teachers and trainers were developed again with general date within 4 sections and questions concerning this section. Table 1 gives an overview about the sections, topics, items and sub-indicators as well as the number of questions concerning the topics and indicators.

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Table 1: Overview about the composition of the questionnaire for the evaluation of best practices in phase A and B

Section	Topic / Item	Questions
Section 1	**Organization, effectiveness of content and delivery**	3 questions
Section 2	**"Voice of user"**	
1	Relation to a green topic and to the National Curriculum	1 question to answer on 3 levels
2	Being interdisciplinary: Drawing upon many academic disciplines and teaching methods	2 questions: 1 question concerning 8 different academic disciplines 1 question concerning 4 different teaching methods
3	Relevance to the daily life of students	1 questions concerning this item with 5 sub-indicators to answer with yes or no
4	Based on accurate and factual professional expertise	1 question to answer on 3 levels
5	Connection to professions in the green labour market	1 question to answer on 3 levels
6	Learning by research and enquiry	1 question about general rating on 3 levels 1 questions concerning this item with 5 sub-indicators to answer with yes or no
7	Activation of the students by hands-on	1 question to answer on 3 levels
8	Enhancement of students' ICT skills	1 question to answer on 3 levels
9	The learning activity supports the development of following social skills…	1 questions concerning with 5 sub-indicators to answer on 3 levels
10	The programme is easily adaptable for …	1 questions concerning this item with 3 sub-indicators to answer on 3 levels
Section 3	**The materials of the programme / practice and general feedback**	7 questions to answer on 3 levels
Section 4	**Feedback concerning the training**	3 questions to answer on 3levels

Evaluation in Phase A and B of the 1st and 2nd Circle of Implementation: Quantitative Facts and Data

1st circle: phase A: Out of these 26 collected best practices 9 best practices were used for the first phase implementation. The detailed evaluation of the best practices is based on the feedback of users on 9 best practices, out of 6 partners, used in sum 18 times.

The number of feedbacks per used best practice differs from 2 to 76. This fact causes a great variety concerning quality and validity of the evaluation outcomes.

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2nd circle: phase B: The detailed evaluation of the best practices is based on the feedback of users on 9 best practices, out of 7 partners, used in sum 13 times. The number of feedbacks per evaluated best practice differs from 7 to 52.

In sum in both phases 444 participants in 142 schools give a qualitative insight in relevant aspects of implementation following the common evaluation questionnaire. In total this means: 15 best practices 12 out of 26 and 3 additional ones.

Overview of the results of evaluation of the 1st and 2nd circle in a 3 level structure

This is not a "ranking" of programmes or implementation processes, it is a short first insight in the feedback of participants, in quite different settings, concerning the committed evaluation items for GreeNET best practices.

- 1st level – lilac – is an indication, that concerning this item potential for improvement in relation to other programmes and practices exists.
- 2nd level – blue – shows a positioning within the GreeNET implementation process – concerning this item – in the average, for excellence additional effort is needed.
- 3rd level – green - is the top performance – out of the view of the evaluating participants – concerning this special item. To hold this performance often is more difficult than to reach them – and a look at the other items is necessary.

Table 2 gives for the overview about explanations per item of the 10 items asked for each practice.

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Table 2: Explanation regarding the i10 items

Item 1	**Relation to a green topic and to the National Curriculum** This item expresses the correlation of a programme with relevant contents of national curricula – and how it performs to make that visible and understandable
Item 2	**Being interdisciplinary: Drawing upon many academic disciplines and teaching methods** This item shows the multi-dimensional approach of a programme, combining elements of various disciplines, and how participants could perceive this approach
Item 3	**Relevance to the daily life of students** This item reflects the connection of a pedagogic environmental programme with the real life of students, out of the point of view of the participants of the evaluated programme, in various aspects
Item 4	**Based on accurate and factual professional expertise** This item gives evidence about the professional expertise that is the base of the implemented and evaluated best practice programme
Item 5	**Connection to professions in the green labour market** This item addresses the aspect to give students concrete insight in "green careers" in professions within sustainable economy
Item 6	**Learning by research and enquiry** This item is focused on the approach of research and inquiry-based learning, differentiated into sub-items, that addresses special aspects of this learning and pedagogic method
Item 7	**Activation of the students by hands-on** This item gives feed-back from participants and evaluators concerning interaction in programmes with materials and hands-on activities used in the programme
Item 8	**Enhancement of students' ICT skills** This item is relevant for the insight into effects of programmes to strengthen ICT skills of students by using best practice programmes
Item 9	**The learning activity supports the development of following social skills…** This item expresses possible effects of programmes on different aspects of social skills, out of the point of view of participants and evaluators
Item 10	**The programme is easily adaptable for …** This item ask for the estimation for possible adaptation and transfer, concerning specific educational needs, students interests and educational aims of a programme

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No.	Country	Practise / Programme	Number of Persons where the practises were evaluated	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6a	Item 6b	Item 7	Item 8	Item 9	Item 10
1	EL	School Garden	98											
2	DE,ES	"HOBOS - To bee or not to bee"	85											
3	AT	Rio 92 +	37											
4	DE	Energy tomorrow	35											
5	EL	Green labs for schools' projects	35											
6	ES	Dikketruiendag	22											
7	ES	Germination Rate	22											
8	ES	Green Ideas	22											
9	ES	Konsumaniatic	22											
10	EL	The ecosystem of lake Pamvotis	15											
11	ES	Hidrophonic Garden	12											
12	AT	School of Eating	12											
13	ES	AgroWeb	10											
14	DE	Rainforest	10											
15	DE	Waste	7											
		Total	444											

Figure 3. Overview about the results of evaluation by users of practices in GreeNET

Prospect for Evaluation results during the validation phase

Based on the recommendations within the implementation phases there is a focus on activities to involve stakeholders as well as companies for more results concerning their expectation for practises for environmental education at school. Following 2 evaluations shall be underlined which are undertaken at the moment by the partners and are assessed and summarizes by STVG:

1. Cross-Check with Companies and Stakeholder: In GreeNET a set of Criteria for identification of "good/best practices" regarding "Green Projects" was developed. An important intention is to compare these criteria with the needs, demands, possible "criteria" for employees in companies concerning "green attitudes". Based by the thesis, innovative, future orientated, effective companies are aware, that "green knowledge, skills and attitudes" could be key assets for success, on the market, in society, and for attractiveness for high qualified job applicants, a specific questionnaire is designed to collect feedback.
2. Each of the GreeNET partners is to organize a set of meetings with stakeholders, in order to present and discuss the findings of the project, and also to investigate the applicability of the project's outcomes in the educational system.

The results will be available as soon as possible on the website of GreeNET.

ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

SCHOOL GARDENS: PROMOTING ACTIONS FOR BUILDING INNOVATIVE LEARNING COMMUNITIES OF PRACTICE

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Background and Introduction

I started building a school garden at the back yard of my school about 10 years ago and ever since it has become a year-round educational programme with impact in the lives of learners, teachers, school communities and organisations. It has turned out to be a long standing commitment, which promotes innovation linked with formal, non-formal and informal teaching and learning activities, alongside with the building of communities of practice for sharing common interests, knowledge, skills, competences and the joy of learning in the field.

Figure 1. The school garden in its initial phases, with built (back) and wooden raided-beds (front) and a greenhouse

Figure 2. Children planting beans in wooden raised-beds in the school garden, which they have started from seed plants

During the school year 2014-2015 a National educational scenario contest has been conducted, under the Institute of Educational Policy (ΙΕΠ) with the title *"School gardens and raised beds: production and disposal of agricultural products"*, with the support of GreeNET and ISE. I acted as a promoter and facilitator of this contest in an attempt to build a community of practice out of this contest. In the beginning of June 2015, eight (8) school scenarios have been selected, amongst others submitted, applying the evaluation criteria described in the contest announcement document. The schools range from kindergarten to primary and secondary, as well as one lyceum. Ten (10) teachers from these schools were selected to attend the summer school conducted at the Primary Science Laboratory in Rethymno Crete (http://efepereth.wikidot.com), during the period of 21st-25th of June 2015.

School gardens as teaching and learning sites

A school garden, needless to say an organic school garden, offers a place to enrich teaching efforts with powerful hands-on activities and experiences that make learning come alive, ideas and concepts come into being. Developing a school garden is not rocket science, neither a "build-it-and-it-will-come" endeavour, but rather an exercise which presents a certain level of complexity and must be "child-generated" in order to be "child-owned". If children lack ownership, they will lack a sense of stewardship. Sustainability requires stewardship. If the garden is to be used, respected and cared for, then stewardship is the key. The foundation of success is not necessarily in proper construction or sound plant selection. Although these are important dimensions of successful organic gardening, it appears that it is not so much the garden, but rather the garden programme and the integrated activities that matter and make the difference, raise the educational added value. Successful (organic) school gardens are built on the foundation of committed people, bearing in mind that although *"there might not be a garden in every school, but there is definitely a school in every garden"*.

ISBN 978-615-5511-06-6

Even a century ago, Dewey, in "Democracy & Education" (1916) contends that

> *"gardening need not be taught either for the sake of preparing future gardeners, or as an agreeable way of passing time. It affords an avenue of approach to the knowledge of the place farming and horticulture have had in the history of the human race and which they occupy in present social organization. Carried on in an environment educationally controlled, they are means for making a study of facts of growth, the chemistry of soil, the role of light, air, moisture, injurious and helpful animal life, etc. There is nothing in the elementary study of botany which cannot be introduced in a vital way in connection with caring for the growth of seeds." (pp. 216-217).*

Therefore "Garden-based Learning" [GBL], within a context of "Inquiry-based Science Education" [IBSE], can be defined simply as a set of instructional strategies that utilize a garden as a teaching and learning tool. The pedagogy is based on experiential education, which is practiced and applied in the living laboratory of the garden. Moreover, GBL has the potential to enrich basic education in all cultural settings. In cases where it is most effective, GBL is a pedagogy that is used with all children. It has something to contribute to each learning style, and to children at each developmental level. Moreover, it cannot be viewed as a "make work" curriculum for slow learners or socially disenfranchised learners, although it has been shown to be a powerful tool in motivating and educating young people who have been identified with such "labels".

Figure 3. Learning is fun in the school garden, an enjoyable educational setting within the school community

ISBN 978-615-5511-06-6

Figure 4. Children producing groceries to be donated to social welfare meals as an act of solidarity to the community

Garden-based learning offers a context for integrated learning. An integrated curriculum is often associated with real-life problems in contrast with a traditional subject–based curriculum. This provides a vehicle for higher order thinking skills as students are challenged to move beyond memorization, to see patterns and relationships and pursue a topic in depth, within a thematic approach. They are engaged in actively and socially constructing and construing knowledge, rather than passively accumulating and accepting information and they also develop analytic and synthetic thinking. At the practical level developing GBL skills raises the importance of (organic) gardening practice, through which children gain firsthand experience with the seed-to-seed cycle, the rhythm and traditions of the harvest, and the taste, touch, and smell of fruits, vegetables, and flowers (Danks, 2010). Proponents of children's garden programs talk of the multiple developmental benefits that school gardens can have on children namely, emotional, aesthetic, and even spiritual in addition to the more obvious social and intellectual benefits, in a variety of contexts (Throp, 2006).

Building learning communities of practice

Communities of practice are formed by people who engage in a process of collective learning in a shared domain of human endeavour, in a sense, groups of people who share a craft and/or a profession. The concept was first proposed by cognitive anthropologists Jean Lave and Etienne Wenger in 1991, with the groundbreaking book on situated learning. It is through the process of sharing information, knowledge, skills, competences and experiences within the community that the members learn from each other, and have an opportunity to develop themselves personally and professionally (Lave & Wenger, 1991). Communities of practice (CoPs) may exist in physical settings, for example, a school, a field setting, or elsewhere in the environment, but members of CoPs do not have to be co-located. In fact, there may also be "virtual communities of practice" (VCoPs) when members collaborate online, such as within discussion boards and newsgroups, wikis, online workspaces and con-folios etc. In a nutshell: *"communities of practice are groups of people who share a concern or a passion for something*

ISBN 978-615-5511-06-6

they do and who interact regularly to learn how to do it better" (Lave & Wenger, 1991). A community of practice is not merely a community of interest, people who like certain kinds of flowers, for instance. The members of a community of practice are active practitioners. They develop a shared repertoire of resources: experiences, stories, tools, ways of addressing recurring problems, in short, a shared practice. This takes time and sustained interaction amongst all members, at any level of expertise they might be, in a framework of collective responsibility and commitment. Practitioners can address the tacit and dynamic aspects of knowledge creation and sharing, as well as the more explicit aspects. In his later work, Wenger (1998) describes the structure of a CoP as consisting of three interrelated characteristics: 'mutual engagement', 'joint enterprise' and 'shared repertoire' (pp. 72–73). A community of practice can exist as long as the members believe they have something to contribute to it, or gain from it.

Schools and districts are organizations in their own right, and they too face increasing knowledge challenges. The first applications of communities of practice have been in teacher training and in providing isolated administrators with access to colleagues. There is an increasing wave of interest in peer-to-peer professional-development activities and the creation of teachers' learning communities of practice (Grossman et al., 2001). In the education sector, learning is not only a means to an end: it is more likely the end product. The perspective of communities of practice is therefore also relevant at this level. In schools, changing aspects of teaching and learning practice is a much deeper transformation, which inevitably takes longer to accomplish, in a gradual and evolutionary mode.

What makes a teachers' learning community of practice succeed depends on the purpose and objectives of the community, as well as the interests and resources of its members. Wenger et al. (2002) have identified several actions that could be taken in order to cultivate communities of practice. Because the nature of a CoP is dynamic, it is important to be designed to evolve naturally and support shifts in focus. It is also important, as well as beneficial, to create opportunities for open dialog within and with outside the community, to enrich perspectives and interact with important agents. It is crucial to welcome and allow different levels of participation in a CoP, such as: a *core group* who participate intensely in the community through discussions and projects, an *active group*, who attend and participate regularly, but not to the level of the leaders and a *peripheral group* who, while they are passive participants in the community, still learn from their level of involvement (most likely to be the majority in a CoP). There should be an attempt to develop both public and private community spaces and participants should explicitly discuss the value and productivity of their participation in the CoP. Influential members of a CoP should coordinate a thriving cycle of activities and events that promote regular meetings (*in vivo* and/or *in vitro*), space for reflection, and evolution of common practices (Wenger et al., 2002). It is significant for members of a CoP to shape their learning experience together by brainstorming and inquiry of the conventional and radical knowledge and wisdom related to their topic, i.e. "school gardens and their impact in school organisations".

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A community of practice out of the educational scenario contest

The teachers contest organized by Ellinogermaniki Agogi (EA), as previously mentioned, was based on the GreenNET "best case scenario" related to school gardens. Participating teachers had to prepare and apply an educational scenario on the topic and share their ideas and implementation steps with selected participants, within a framework of a summer school. The main objectives of the summer school have been the following:

- to bring together colleagues with relevant interests in school gardens, share educational scenarios and activities conducted during the school year 2014-2015;
- to develop and share ideas for further implementation in educational contexts and settings in an attempt to create a teachers' learning community of practice;
- to engage in activities, small project constructions, table and virtual games on gardening etc. that have already been developed and extended in several cases;
- to familiarize teachers to open educational resources, repositories and authoring tools available for the development of educational scenarios;
- to develop ideas for further implementations in action and forthcoming collaborations in European and national projects.

At the beginning of the summer school the teachers were introduced to the history and development of school gardening in Greece and in other contexts, based on evidence from available resources (cf. http://efepereth.wikidot.com/garden-resources). During the second and third day of the summer school the teachers got involved in several hands-on projects, activities and constructions. We started from the idea of "hot boxes" as it had been developed in the 18th century, as a basic principle for passive solar constructions, such as greenhouses, solar dehydrators and solar cookers and then we got down to the construction of several such devices (cf. http://efepereth.wikidot.com/solar-cookers and http://efepereth.wikidot.com/solar-dehydrators for example). We also had an introduction to composting and then we created simple decomposition columns out of plastic bottles, whereas we also studied and explored the compost chambers out in the school garden (cf. http://efepereth.wikidot.com/garden-compost). The teachers also got involved in microscope studies linked to the seminal work of Robert Hooke's *Micrographia* (1665), with self made microscopes, where they examined specimens from the school garden, such as seeds (thyme, petunia), plants (leaves, flowers, roots etc.), insects (ants, bees, isopods etc.), with commitment, interest and high enthusiasm (cf. http://efepereth.wikidot.com/hipst). Furthermore, the teachers have been introduced to basic principles of biological pest control, as the beneficial action of predators, parasites, pathogens, and competitors in controlling pests and their damage in the garden plants.

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Figure 5. Constructing decomposition columns out of plastic bottles, as an introductory activity to composting

Figure 6. Teachers who participated in the summer school out in the school garden, under the olive tree

During the fourth day of the summer school the teachers were involved in creating educational scenarios with ODS and ISE authoring tools, implementing metadata on their scenarios and practiced uploading them to platforms and repositories. They worked with their laptops and managed to acquire basic skills in these processes, also creating their school repository to use in the coming school year. The teachers were also introduced to the idea of "communities of practice" such as the "My school garden" community (http://portal.opendiscoveryspace.eu/community/my-school-garden-o-sholikos-moy-kipos-70514), or groups of special interest, created in social media (e.g. https://www.facebook.com/groups/1587449181539164/). During the final day of the summer school the teachers presented their work described in the educational scenarios they have implemented in their schools, which are to be uploaded in the community page (http://portal.opendiscoveryspace.eu/community/my-school-garden-o-sholikos-moy-kipos-

ISBN 978-615-5511-06-6

70514) and in the wiki of the Primary Science Laboratory (cf. http://efepereth.wikidot.com/summer-school-greenet-2015).

The selected scenarios utilized the "best case" approach of school gardens, providing important ideas for further enhancement and elaboration, such as the following:

- project development within a cross curricular subject area, interweaving science, language, mathematics, ICT, geography, arts & design etc., in primary as well as in secondary education;
- inquiry based science activities and experimentation from early ages to high school (Lyceum);
- connections with a historical perspective of agriculture and school gardening, throughout the past century, linked with nowadays practices;
- provision and cultivation of ideas relevant to sustainability and sustainable development;
- sensitization of young pupils in early primary education and kindergarten as well as in children of special needs;
- inclusion and application of contemporary gardening techniques, such as hydroponics and composting, conducted within innovation in a school teaching and learning environment.

Overall, the teachers enjoyed the content, processes and hospitality of the summer school, making it a successful endeavour, as it is documented in the evaluation questionnaires they have filled in and in their concluding remarks. The need for the development of a community of practice on school gardening has been highlighted and realized as a necessity for further exchange and development, also appreciated in a highly participatory mode of interaction throughout the whole process.

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ISBN 978-615-5511-06-6

ISBN 978-615-5511-06-6

OEI2

Open Educational Ideas and Innovations –
towards open idea and innovations sharing for learning, education and training

Website: http://idea-space.eu

Runtime: 10.2013 – 02.2016

Supported / co-funded by: Lifelong Learning Programme – ERASMUS multilateral projects

Partners: University of Jyväskylä, Finland (coordination); Duale Hochschule Baden-Württemberg, Germany, ESCP Europe Business School Berlin, Germany; National Centre for Scientific Research Demokritos, Greece; Vytautas Magnus University, Lithuania

Project representative to be contacted for further info: Henri Pirkkalainen (henri.j.pirkkalainen@jyu.fi)

The project aims at enabling Open Education at an early stage: instead of sharing complete Open Educational Resources (OER), we aim at sharing ideas in the early design process. This process will create a fundamentally different uptake of OER by creating Emotional Ownership for the resources in progress.

Our approach tackles the main barriers of OER: the not-invented-her syndrome, curricula differences and lack of motivation. In simple words: we bring educators together sharing ideas and early stage developments, so that they can collaborate on open education. This brings a variety of benefits

1. Boosting OER uptake by involving educators at an early stage.
2. Creating collaborations between educators across borders.
3. Increasing cultural and curricula understanding between educators.
4. Creating collaborations and virtual mobility activities.

The project is organized as following:

- **Engagement and requirements**: We ran workshops across Europe to create awareness on Open Education - we created future scenarios (how to implement the OEI approach) and gather requirements. The main outcome was an understanding of the needs as well as initial awareness.
- **Idea Sharing Space** allows educators to share/post ideas, find collaborators and - based on OEI - create OER together using our creativity, authoring and collaboration tools.
- **Good practices** are being created in initial trials and larger scale validations, leading to future recommendations.

Main target groups of the project: Educators, learners, educational authorities, and technology providers.

Significant public results: An online idea space.

Publications: A theoretical overview on "Emotional Ownership" and "Idea Sharing"; A good practice guide how to embed to embed Open Educational Ideas into learning and teaching (programmes).

ISBN 978-615-5511-06-6

OEE

Open Education Europa

Website: http://www.openeducationeuropa.eu/en

Runtime: 6.2014 – 11.2015

Supported / co-funded by: Erasmus+/EU

Partners: P.A.U. Education S.L., Barcelona, Spain

Project representative to be contacted for further info: Agnes Aguiló (agnes.aguilo@paueducation.com)

The Open Education Europa (OEE) portal is an initiative of the European Union and its main goal is to offer access to all existing European Open Educational Resources in different languages in order to be able to present them to learners, teachers and researchers.

Open Education Europa is a dynamic platform built with the latest cutting-edge open-source technology, offering tools for communicating, sharing and discussing. The portal is structured in 3 main sections:

- The FIND section showcases MOOCs, courses, and Open Educational Resources by leading European institutions. Each institution is also featured in this section alongside the MOOCs, courses, and the Open Educational Resources it provides.
- The SHARE section is the space where portal users (scholars, educators, policymakers, students and other stakeholders) come together to share and discuss solutions for a diverse range of educational issues by posting blogs, sharing events, and engaging in thematic discussions.
- The IN-DEPTH section hosts eLearning Papers — the world's most visited e-journal on open education and new technologies —, provides an exhaustive list of EU-funded projects, and highlights the latest news about open education as well as the most relevant recently published scholarly articles.

Main target groups of the project: Teachers, lifelong learners, education leaders, education professionals, researchers, policy makers.

Significant public results:

1. *Eleaning papers* journal (http://www.openeducationeuropa.eu/en/elearning_papers) adds a new dimension to the exchange of information on open education, OER and ICT in education in Europe and stimulates research. As such, the articles provide views regarding the current situation and trends in different communities: schools, universities, companies, civil society and institutions. Through these articles, the journal promotes the use of Open Educational Resources and new technologies for lifelong learning in Europe.

2. *Open Education Scoreboard* (http://openeducationeuropa.eu/en/open_education_scoreboard). The aim of this scoreboard is to highlight the huge potential that European institutions have in the world of OER and to help visualize this potential by compiling the existing European-provided MOOCs available on different open websites.
3. *Education in the Digital Era* high level conference (http://www.openeducationeuropa.eu/en/edu-in-digital-era) took place on December 11th, 2014, in Brussels, Belgium. Ministers, leaders of educational institutions, and educational innovators convened to discuss the opportunities and challenges of adapting education to a faster changing, digital society and economy, shaping education's place and priority in the EU's sustainable growth agenda.
4. *Open Education Groups:* A number of groups created by users and OEE aim to support innovative initiatives, projects, events enhancing interaction between all OEE users. Example: The three groups that supported the Education in the digital era conference (http://www.openeducationeuropa.eu/en/edu-in-digital-era/themes#163018) and are still active and open to all the interested OEE members.

ISBN 978-615-5511-06-6

eLene4work

Learning to learn for new digital soft skills for employability

Website: http://www.eLene4work.eu

Runtime: 12.2014 – 10.2017

Supported / co-funded by: Erasmus+ Cooperation for innovation and the exchange of good practices, Strategic Partnerships addressing more than one field

Partners: eLene4Work Coordinator: Fondazione Politecnico Di Milano, IT; see more at: http://elene4work.eu/project-description-2/list-of-partners/

Project representative to be contacted for further info: Argiris Tzikopoulos, argiris.tzikopoulos@sen.org.gr (partner presenting the project at the Athens Conference); Project coordinator: Matteo Uggeri (info-eL4w@eden-online.org)

The aim of the eLene4work project is to help students and new entrepreneurs develop soft skills (often also referred to as 21st century skill, such as problem solving in a creative way, learning to learn, cooperation, effective and clear communication, adapting to different cultural contexts, managing conflicts, showing endurance in complicated or stressful situations, etc.) skills required by companies of all sizes nowadays. The eLene4work outputs and services, therefore, are also aimed to help companies exploit the digital talents of young employees. The project proposes a strategic partnership whose goal is to test and monitor the possibility offered by various means of open and distance learning opportunities such as MOOCs and OER to address the demand for digital soft skills (like e-collaboration, digital communication, social network participation, social media management and web 2.0 activities in general) formally not taught at universities but desirable by most employers on the labour market.

The aim of the eLene4work project is to allow students to:

- autonomously identify their own:
  - gaps in soft skills and competences, in order to develop or improve them;
  - potential in digital soft skills, to increase their professional attractiveness on the labour market;
- autonomously learn how to:
  - fill their skill gap using MOOCs (and other OERs)
  - include in their CV their soft skills and digital soft skills in order to enhance the opportunity to enter the labour market.

Students will learn to learn how to use and exploit their own digital competences and soft skills on the labour market.

Main target groups of the project: The various project outputs are being developed to bridge a clearly identifiable gap between what employers seek and job seekers can offer in terms of today's essential digital skills. From the educational point of view both VET institutions and universities (deans, presidents, rectors, teachers as well as students) can benefit from the eLene4work services, while on the other hand managers, HRs, entrepreneurs, chambers of commerce and company associations are also primary target stakeholders. The project's secondary target audiences include instructional designers, e-learning experts, researchers and policy makers.

Significant public results: The main results of *eLene4work* will be the following:

Self-evaluation tool: an online questionnaire for students' self-assessment of soft skills and digital soft skills resulting in a "Personal development plan".

O*rientation tool for students and young workers*: a coordination tool specifically being developed for the students, who will approach their personal development in soft skills and soft skills 2.0, drawn on the results produced within the project primarily the Comparative analysis on state of the art of soft skills and soft skills 2.0, the 2 rounds of Focus groups.

Focus groups are organized with i) students and young workers; ii) teachers and HR responsible; During the summer of 2015 focus group interviews took place in Poland, Italy, France and Spain. For updates you may visit the eLene Network's public Facebook group: https://www.facebook.com/groups/337054472985447/

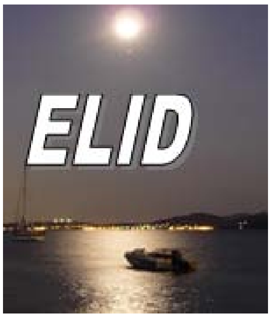
Personal Journal: a template to give a method to students about how to learn autonomously and further develop themselves and to evaluate the whole learning path held through the MOOCs.

Lesson learned kit: a set of recommendations targeted at different groups, with a collection of all the experience developed within the project, with a particular attention to the filled evaluation of the students' learning experience and the tutoring and monitoring of the students' path.

ISBN 978-615-5511-06-6

ELID

Exposed to Light – Immersed in Darkness



Website: TO BE CREATED

Runtime: 9/2015 – 5/2016

Supported / co-funded by: To find

Partners: To find

Project representative to be contacted for further info: Asimina Kontogeorgiou, akontogeorgiou@gmail.com

In 2015 we are celebrating the International Year of Light and Light-based Technologies (IYL2015). This initiative sanctioned by the United Nations and UNESCO aims to bring awareness about the importance of light in our lives, its potential to the promotion of sustainable development and to enhance our knowledge frontiers. Following the IYL2015 summer school, we propose to focus on LIGHTING.

> *Lighting is the deliberate use of light to achieve a practical or aesthetic effect. Lighting includes the use of both artificial light sources like, as well as natural illumination by capturing daylight. Daylighting (using windows, skylights, or light shelves) is sometimes used as the main source of light during daytime in buildings. Proper lighting can enhance task performance, improve the appearance of an area, or have positive psychological effects on occupants (Wikipedia).*

While *light* comes from the natural environment, *lighting* is a human intervention which is dictated by needs and technical possibilities which go hand-in-hand with our development.

Archimedes (287 BC - 212 BC) invented the icosahedron, which determines the way the soccer ball is put together. His timeless demand "Don't disturb my circles" is a message of inner peace and persistence in the value of creation. This concept of Light Art created by G. Paissidis is a contemporary expression of historical consciousness.

> *'Darkness occurs in the absence of light' Aristotle says, drawing attention to the action of getting dark as an act of lighting. Darkness is important as a visual stimulus in the context of variety, or, more exactly, of the full use of the*

> *broad range of visual stimuli which human optical apprehension can take in. Man's night vision, however, is activated only disjunctively. Those who live exposed to the lights of the city do not have the opportunity to be aware of this capacity (Paisidis, 2015).*

In any case, *light pollution* is a growing problem due to excess light being given off by numerous signs, houses, and buildings. This is often wasted light involving unnecessary energy costs and carbon dioxide emissions. Well-designed lighting sends light only where it is needed without scattering it elsewhere (Lynn, 2010; Claudio et al. 2009)

Lighting, in general, is a subject which is not discussed in schools of any level. We have the intention to open a discussion among teachers and then among students, about different topics related to lighting. Some of them are mentioned above. We hope that during the synergy, we will have the opportunity to share personal experiences from our exposure to the diversity of natural light manifestations, to develop ideas and collaboration plans by interactive working group activities. Also, throughout the Project ELID, we will invite experts in order to offer to teachers the opportunity to be **Exposed to Light** and be **Immersed in Darkness,** so that they will be experienced the diversity of natural light manifestations.

We intend to organize seminars, where teachers will be implemented in hands-on/minds-on activities in order to express feelings, moods, intentions, etc. in response to relevant visual stimuli (lightning, lava volcanic explosion, aurora borealis, shooting stars, sunset, solar eclipse, shooting stars, sunset, sun eclipse, shininess – stilvi, etc). They will express themselves with light with suitable equipment cheap (lenses, mirrors, gelatines etc. or loaned by contributing specialized company (ex. Philips). Also, we intend to call teachers to connect darkness and shadows with the myth of Plato's cave (Paisidis, 2013).

Moreover, we will encourage teachers to implement some of these hands-on / minds-on activities in their classrooms in order to sensitise their students about lighting. Example of classroom/outdoor activities is presented here under:

Students will be called to experience a nightscape far from the lights (understand that their night vision increase in the darkness, notice how many stars they can see, express their feelings). Then they will be asked to experience a usual urban nightscape in the middle of their city and make the same observations. After that, they will work in small groups: Write down the differences they notice, find information about light pollution. In the classroom groups will present their work, discuss the issues that are identified. Finally, groups will express themselves by writing a text or a poem, drawing or taking a photo.

We believe that is very important for the students to be able, as future citizens, for example

> *not admire a confusion of visual stimuli in an urban nightscape lacking elementary order, where the lighting palimpsest in congested nightscapes is burdened with densely arranged lit monuments and arbitrarily arranged luminous signs (Paisidis, 2011).*

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Main target groups of the project: Teachers in Primary School, Science teachers in Secondary school

Significant public results: Events with experts, teachers, students and public, repositories, case studies: buildings or objects lit in different ways / public discussions.

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ISBN 978-615-5511-06-6

Umweltlehrgang VWG/Siemens

Environmental awareness training

Website: http://wnoe.vwg.at

Runtime: 10.2011 – ongoing

Supported / co-funded by: –

Partners: –

Project representative to be contacted for further info: MMag. Regina Schraick (Schraick@vwg.at)

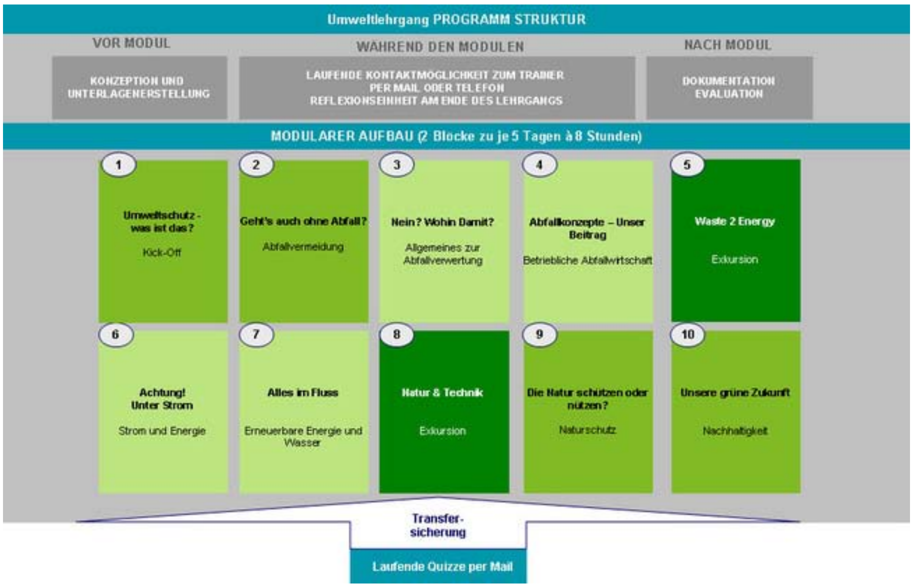
In spring 2011, the green company Siemens approached the educational institute Volkswirtschaftliche Gesellschaft (=VWG: Association for Education and Economics) with the intention of integrating the topic "environmental protection" and all relevant spheres of activity as a permanent component into its apprentice program.

Due to fact that the creation of environmental awareness has to be initiated at an early stage and that apprentices represent the company's future, they were selected as participants in the implementation of the pilot project.

A concept was created to convey the necessity for environmental protection in general and the scope of action of each individual, especially in a company context. Siemens also trains deaf apprentices. Therefore, it went without saying that they should also take part in this training.

The project aims to raise, in accordance with the action area F of the Austrian Master Plan for Green Jobs of the Federal Ministry of Agriculture, Forestry Environment and Water Management, the awareness of apprentices for environmental issues and thus to improve personal actions and consequently dealing with environmental issues in the workplace.

An additional aspect is the communication of environmental initiatives from a global perspective. Through this holistic approach, the apprentices recognise the importance of environmental issues in all facets of their life, thus ingraining the concept sustainably. The seminar consists of 8 Days of trainings and 2 days of excursions. Each day lasts for 8 units and is conducted by coaches who also work in the environmental field.



Topics such as waste avoidance and waste minimisation were of particular importance, followed by forms of energy and the use of renewable energy. At the completion of the course awareness for the importance of conservation for Austria was raised and the sustainability in a private, professional and social area was promoted. In order to make the topic more tangible the seminar is – as stated before – rounded off with two days of excursions to environmental and energy-related facilities. Destinations visited included the waste plants of MA 48, the hydropower plant Freudenau, the power plant Simmering and the Forest School Lobau.

Main target groups of the project: Apprentices.

The course aims to raise environmental awareness and sensitivity of apprentices.

Through experience-oriented approaches, exercises and examples appropriate for young people, the apprentices will be made aware that they can contribute, through their investment and consumption behaviour, to save energy and reduce emissions. This leads to a more efficient use of scarce resources and a more responsible approach regarding environmental issues. Furthermore, the course aims to demonstrate that even small actions can lead to large environmental changes and savings. Mindful consumption, investment and actions at the workplace can reduce cost and save energy.

This is also experienced through various exercises during the course, by raising awareness of waste, energy efficiency and sustainability, thus, in the long run, guaranteeing a more efficient approach toward the environment.

ISBN 978-615-5511-06-6

GO EcoSocial Training

GO EcoSocial Training

Website: http://goecosocial.at

Runtime: 11/2011 – 11/2015

Supported / co-funded by: Federal Ministry of Science, Research and Economy – Austria

Partners: change each year

Project representative to be contacted for further info: Ökosoziales Studierendenforum Österreich (office@oessfo.at)

The 'GO EcoSocial Training' is a Vienna-based training course offered annually by the host organisation 'Ökosoziales Studierendenforum Österreich'. Its aim is to educate groups of students of various subjects (approx. 30 in total) in ecosocial market economy as well as sustainability in general. The course is divided into 4 modules with different thematic priorities.

In the first module, participants learn about the overall concept of the ecosocial market economy and the Global Marshall Plan. Since it is the most relevant module for the students to be able to become multipliers, the first module usually extends over a whole day (approx. 8 hours). Past speakers include, among others, former Austrian vice chancellor Dr. Josef Riegler and former general secretary of the 'Ökosoziales Forum Österreich' Klemens Riegler-Picker.

Based on the newly gained knowledge, the following modules focus upon certain aspects of sustainability, differing from year to year. Topics so far have been as diverse as 'ecosocial entrepreneurship', 'environmental ethics', 'sustainability communication' and 'systems thinking'. In collaborating with a multitude of organisations and individuals, it is assured that issues are adequately addressed from different perspectives. These modules are usually scheduled for 3 - 4 hours.

Since it is one of the main goals of the GO EcoSocial Training not only to generate theoretical but also practical knowledge, each module includes a variety of group exercises. These exercises challenge the students to think creatively and apply what they have learned and also help develop a sense of community. Some of them are self-contained while others are interconnected, however, all of them produce explicit output such as posters and sketches.

Main target groups of the project: students.

Significant public results:

Participants receive official certificates upon participating in the first and at least 2 out of the 3 following modules. They get the chance to connect with the organisations involved, which, for example, led to a job offer for one of the students in 2014.

As the GO EcoSocial Training is a particularly ambitious project of the ‘Ökosoziales Studierendenforum Österreich’, an extensive review is usually included in the organisation’s annual report.

ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

SUPPORTING ODS SCHOOLS IN CYPRUS: EXPERIENCE OF A NATIONAL COORDINATOR

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Introduction-Background

Open Discovery Space is the "largest e-Learning project ever launched by the European Commission" (Sotiriou et al., 2013). It employees a multi-lingual web portal with a core focus of the creation of "a community of teachers by teachers" (ODS platform) who use e-Learning resources. The main idea of the ODS platform was the amalgamation of several existing e-Learning portals under one roof, so that teachers will have access to a rich world of educational content stretching right across the curriculum.

The Open University of Cyprus was the ODS Cyprus National Coordinator (NC) whose main task was to attract school participation (from seven to thirty to a hundred schools in the three years of the project) and offer local support to teachers involved in the project.

The main challenges we faced were related to the size of the country and the previous Cypriot experience in school support for ICT.

The small size of Cyprus and its educational system (less than a million people with about 500 schools) has some clear advantages for a project like ODS: personal contacts go a long way both in the apparatus of the Ministry of Education and for reaching schools and teachers. However, the goal of involving 100 Cypriot schools, i.e. 20% of all schools was excessive.

ICT in Cypriot Education has a relatively long history and is supported in several ways: Informatics as a subject is taught in Cypriot high schools since 1986. A large number of EU-funded projects for ICT in schools have been implemented since 2004 when Cyprus joined the EU and we had to compete for the attention of active teachers and schools and to change attitudes in schools which had refused to participate in similar, if smaller scale, projects.

The aim of this paper is to present our approach in implementing ODS in Cyprus.

Our Approach

In the first year our task was to engage seven Cypriot schools in innovative actions that would lead the way in the use of modern technology and practices within the school setting. During the second year of the project we engaged more than thirty Cypriot schools. At the final stage of the project, a total of fifty-five Cypriot schools were involved. Cooperation and coordination with the Ministry of Education and the Cyprus Pedagogical Institute (CPI) was fundamental for the engagement of the schools. The aim of CPI is to ensure the continuous training of teachers at all levels, to inform them about the latest trends in education, document research and theoretical steps to educational policy and to facilitate teachers in their quest for professional and personal development. Educational Technology is one of the three departments of the CPI. Supervisors (inspectors) for ICT exist for both elementary and middle education. We managed to have the official 'adoption' of the project by the Ministry through the Pedagogical Institute. A joint team acted as an informal steering committee. Digipro, a Cyprus-based eLearning company and ODS partner, also joined forces with a special regional and resource focus.

As NCs, we organized a number of workshops (change agent workshops, practice reflective workshops, summative workshops), dissemination activities and interactive presentations in order to gain the interest of the target audiences. Also, ODS teachers had the opportunity of participating in project summer/winter schools, and competitions mostly supported through the Erasmus+ programme. We assisted teachers to reflect on their current situation in order to complete the e-maturity questionnaires and their action plans in which they declared, among others, their needs and their vision for their schools. In depth-discussions with active ODS teachers were held and the results were communicated to ODS during the project meetings. Moreover we contributed to the authorship and formative evaluation of the headmaster booklet and proposed final refinements for it. Also, we supported the participation of ODS schools at the annual ICT conference organized by the Pedagogical Institute of Cyprus (Ministry of Education).

Personal contacts played an important role: informal communication channels (word of mouth from members of the Cyprus ODS team) was the starting point for ODS involvement of several school coordinators. In the second year we had to widen the school involvement and participation. During the initial meeting of the OUC support team with the school coordinators who had expressed interest in ODS, we promised on-site school visits. The main purpose of the visits was to inform about the goals and affordances of ODS, to involve the principal and empower the coordinator. We went to all registered schools -which was positive in spite of technical problems of the ODS portal which disheartened many schools and teachers: early promotion of future affordances leads to interest lost.

We also conducted a number of webinars. Eight local webinars regarding the use of educational scenarios (in Greek) were held using Google Hangouts, showcasing templates and scenarios based on these templates. One webinar was conducted in order to support ODS teachers in their participation at the ODS contest. An additional webinar was conducted in order to train teachers in using the ODS platform and the Authoring Tool.

As the National Coordinator, we designed and created eight activity scenarios which were identified as best practices and tested in real conditions in Cyprus. They have been uploaded and described in the ODS Community portal. They range from "Mapping Historical and

Religious Monuments”[1] and “Dietary Habits of Europe”[2] to “Shadow Theatre - Collaborative Online School Performance”[3], “In search of the lost artifact”[4] and “Let’s teach programming, let’s learn how to code”[5].

Other ‘validation’ activities, such as national workshops and contents for students and teachers were organized. We organize a ceremony at the school of the ODS scenario contest winner teacher. It was combined with a workshop in which the ODS platform and the scenarios were shown to the teachers of the respective ODS school in conjunction with the explanation of Resource-Based Learning as a method that could be linked effectively with the use of Open Educational Resources (Kanwar, Uvalić-Trumbić & Butcher, 2011). More specifically, the RBL approach was explained as the means of moving from plain ‘consumption’ of (digital) data to meaning making while a) taking into account the context, b) exploiting the affordance of ICT tools, c) providing scaffolds and d) using Open Educational Resources (Hill, & Hannafin, 2001).

Also, we organized an eParenting Sceminar which included a presentation of the ODS portal to primary and secondary teachers and representatives from the Pancyprian Parents Union. Emphasis was given on the Academies and Educational Content of the platform, from which parents could locate appropriate content to use with their children, as well as the prospect of participating in online seminars. The availability of content, teachers and webinars, can enable parents to become actively engaged in supporting their children, with beneficial academic results (Epstein et al., 2009). In terms of means of communication used, informal meetings and online conversations took place with small groups of stakeholders as well as more formal meetings in order to coordinate with the Pedagogical Institute and the Ministry of Education.

Project Results

Many activities took place during the three phases of the project:

1. The virtual visit of seven high schools to CERN. The event was covered by a local TV station. For this action, coordination for the communication among the teachers and a Greek speaking member of the communication group at CERN was established. Also, many technical problems were resolved.
2. Participation of the primary school of the Palaichori (a village near the city of Nicosia) at the educational contest 'AGRO Web: traditional products in my area' which aimed to inspire students to engage in activities relevant to the agricultural production, the local

[1] http://portal.opendiscoveryspace.eu/community/senario-1-hartografisi-istorikon-thriskeytikon-mnimeion-689500
[2] http://portal.opendiscoveryspace.eu/community/senario-2-diatrofikes-synitheies-ton-katoikon-tis-ee-689511
[3] http://portal.opendiscoveryspace.eu/community/koinotita-ypostirixis-gia-senario-3-theatro-skion-diadiktyaki-synergatiki-parastasi-689518
[4] http://portal.opendiscoveryspace.eu/community/senario-4-se-anazitisi-toy-hamenoy-apolithomatos-689523
[5] http://portal.opendiscoveryspace.eu/community/senario-7-mathoyme-programmatismo-grapsoyme-kodika-689552

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community and economy. Information about the contest Agro Web was given to the principle of the primary school Palaichori and many questions were answered by the members of the ODS team at Cyprus.

3. Partnership among primary schools of Cyprus and Greece. This action was called "Traditional professions" and focused on extinct professions. Schools from Cyprus and Greece that wanted to get involved with this specific action were brought together through online meetings. Technical support was provided to the coordinators of the schools that were involved in this action. Specifically, guidelines for the Google Hangouts were given in detail.
4. Participation of three Gymnasiums in the Eratosthenes experiment. Guidelines and technical support were given to the coordinators of the schools that participated in these actions.
5. Utilization of virtual and augmented reality in the Language Lesson in Elementary Education from the fourth elementary school Aradippou (in Larnaka). The coordinator of the participating school needed help for finding suitable content to incorporate virtual and augmented reality in the classroom. A scenario for this purpose was designed in coordination with the teacher of the school.
6. Development of a virtual museum for traditional tools from the Primary schools of Pefkios Georgiadis (in Nicosia) and Athienou (in Larnaka). Information about the software Artsteps[6] that assisted teachers to design the virtual museum was given.
7. The elementary school of St. George (in Limassol) in collaboration with Frederick University (Cyprus) organized educational robotics courses. The title of the action was "Let's learn programming, let's learn code". Assistance for the design of the learning scenarios was given to the coordinator of the primary school.
8. Agios Spyridonas Primary, using video conferencing, interactive whiteboards and other technologies, managed to virtually include the only student of Gaydos Primary, the most remote southern part of Europe, in a classroom of 20 students (Science), thus helping the child collaborate with other students. The project, which persisted for two school years, received coverage by media – including local and Greek national TV and newspapers – of the inclusion of students from remote and isolated schools in normal-sized classrooms of a city school.

One of our schools was among the pan-European winners. Four scenarios from an ODS school received awards, three for innovative practice and another from the participants during the annual ICT conference organized by the Pedagogical Institute of Cyprus (Ministry of Education). The same school (primary school of Agios Spyridonas, located in Nicosia) was also among the winners of the ODS Innovative School competition.

Regarding support coming from the ODS school headmasters, the majority of them didn't play any significant role in their school's participation and involvement in the ODS endeavour in Cyprus.

[6] http://www.artsteps.com

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Figure 1. High density of ODS Schools in Cyprus

Discussion and Conclusions

Many teachers have gained many from their involvement into the ODS project. Mainly due to the fact that they were enabled to be informed and trained of how to use new technological tools that could assist them to integrate their teaching expertise and their students learning experience. In addition they found colleagues for other countries and schools that proved to be valuable co-workers and friends that shared the same enthusiasm and passion for their work.

Unfortunately, there were teachers that although much help and ample opportunities were given to them, they didn't take advantage of them. In many cases the school management and even the inspectors weren't properly informed thus couldn't support and acknowledge their effort of trying to incorporate innovative ways of learning into their class. Reasons that made teachers more hesitant towards what the ODS had to offer were identified through the workshops that were organized in Cyprus. They include the lack of:

- authenticity control over the digital resources uploaded in the ODS platform;
- intellectual property rights; teachers claimed that for them this is an issue since the ODS repository points to resources that reside to other repositories and each platform has its own rules, and this creates reservations and hesitation on behalf of the teachers;
- clear and strong links of the resources that reside in the ODS portal with the national curricula;
- continuous feedback and support in resolving technical issues, issues related to the content to be taught and pedagogical issues (this will help them in seeing ODS as a sustainable endeavour).

Good practices for overcoming resistance to change that were identified during the discussions in the workshops include:

ISBN 978-615-5511-06-6

- integrate the ODS repository the "e-epimorfosi" repository (launched by the Ministry of Education), which they are already making use of and in which themselves (or their colleagues) have uploaded trusted materials;
- create a digital environment like Facebook but with the extra functionalities that are typically provided by an online repository;
- raising awareness concerning intellectual property rights and licensing;
- populate the ODS repository with materials related to their teaching practice, in addition to subject-specific materials.

Being involved in the development of the pedagogical concepts and tools of ODS was positive for our role as a NC. Great experience was gained of what teachers expect from an educational platform. Since one of the platform's main role was to create networks among teachers it should had borrowed characteristics from the platforms that support the social media such as Facebook.

Assigning a person especially for supporting schools, organising visits, webinars and f2f meetings was an effective idea, as teachers often are not eager to stray from the safety of traditional of teaching into innovative ways incorporating ICT. Teachers who were actively involved in ODS complained that they had to spend many hours to design and organize lessons based in technology.

We did not succeed in substantially changing the level of school e-maturity. Only a few teachers from each school not previously involved in ICT in education were attracted. The ODS portal has been a primary tool and obstacle. Especially during the crucial 2nd year of the project, the state of the ODS portal was an important reason why we were unable to gather momentum. From discussions with the change-agent teachers that were held during one of our practice reflection workshops focusing on the degree in which the project met their expectations, and also asking whether the change-agent teachers wanted something different, the main conclusion about the second year of the project was that in some cases the learning goal result of the activities was not achieved due to technology related factors. The ODS platform was considered difficult to use, and was often not utilized in the activities Supporting both primary and secondary education was deemed important. Having learning objects and activities in Greek was an important asset for ODS, although many teachers were able to use material in English as well.

In hindsight, the project was too big and too short. Some of the original goals regarding the involvement and the impact expected were unrealistic.

ISBN 978-615-5511-06-6

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

IMPACT ON CURRICULA, SCHOOLS AND EDUCATIONAL SYSTEM: OPEN DISCOVERY SPACE LESSON LEARNT

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Abstract

Information and communication technologies (ICT) can provide students and teachers with access to an abundance of educational resources that might not otherwise be available. "Open Discovery Space" (ODS) is a socially-powered multilingual virtual open learning infrastructure capable of boosting the adoption of eLearning resources. The aim of this research is to explore, analyse and synthesize the lessons learnt and findings so far from the implementation of ODS in schools all over Europe after three years of the project. The results presented in this paper have been gathered from interviews and a survey study with the educational stakeholders (i.e. teachers, curriculum developer and researchers) across Europe aimed at gaining a better understanding of the teachers and student's needs, the challenges and difficulties they face, as well as their ideas and views about ODS innovative approaches, practices, processes and tools for meaningful teaching and learning. The findings will also help to identify the strategies and initiatives related to measuring and demonstrating the effective use of ICT for education with regard to the teaching and learning practices and processes to enhance the performance.

Key words: Impact on Schools, Curricula, educational systems, ICT, learning technologies.

Introduction

An international study on educational ICT in 23 educational systems in North America, South America, Europe, Africa and Asia found significant differences between countries in the availability of networked ICT in schools (Law et al., 2008). Means et al. (2009) conducted a meta-analysis of ICT studies of online versus face-to-face learning in K-12 settings published between 2004 and 2008. Across these studies, online learning was knowingly more effective than face-to-face (Ni, 2013). A number of ICT studies have established that computers can have a positive impact on student motivations, such as their attitudes toward technology or the subject matter. There are other studies that go beyond traditional measures of student learning which includes creativity, complex problem solving, inquiry-based learning, modelling, game based learning, and the collaborative learning. Hermans et al. (2008)

conducted a study showing that constructivist beliefs use of computers in the classroom has the positive effect, however, traditional beliefs have the negative impact. Much of the research in OECD countries shows a gap such that boys have more experience with technology than girls and that girls are more anxious about technology than boys (Blackmore et al., 2003).

Innovation is often regarded as a highly demanding challenge that usually meets resistance because of its intrinsic complexity (OECD/CERI, 2009). In reality, as pointed out by Ellison (2009), innovative education sectors require de-centralization of decision-making over curricula and organisational structure to the local level (districts/schools), allowing new ideas and practices to emerge from the bottom up. Policymakers need to create adequate conditions (such as institutional space and incentives structures) for risk-taking on the part of educational actors, thus empowering teachers and school leaders to experiment and adopt innovative pedagogical approaches. As it also implies a slow process of change, innovation frequently fails to become systemic and to yield a sustainable outcome (Fullan, 2011a; 2011b; Hannon, 2009; Shapiro et al., 2007). The OECD Innovation Strategy (OECD, 2010), emphasizing the need for a horizontal policy approach. This promises greater coherence, better performance and a structure that is more appropriate for the central role of innovation in society today.

Curricula structure differs from country to country, in many countries as curricula define the particular contexts and demands that learning resources for school education needs to take into consideration. As the participants of ODS stated, it is impossible to know the differences between all regional and national curricula. ODS usefulness lies in providing learning pathways, scenarios and use cases, as well as the organisation of available resources to particular curricula and learning contexts (Richter et al., 2014.) of the user.

To grasp the impact of ODS we first give an overview of the curricula structure of the countries involved, observing similarities and differences among them. Then we classify the relevance / impact levels of ODS on the curricula, introducing 4 levels characteristic of the penetration of ODS into the educational practice.

We expect that sheer relevance (level 0 impact (ODS completely fit into the curricula both at school as well as at national /regional levels) will be quite strong, level 1 impact (indicating some change requests at school level without any conflict with the national /regional level) somewhat weaker, level 2 impact (adaptation need at national / regional level) even less characteristic, while level 3 (indicating the need of cooperation among national curricula stakeholders across the EU) impact will rarely be observable.

Conceptual –Theoretical Framework

The ODS addresses the challenge of modernising school education by engaging teachers, students, parents and policymakers and developed a multilingual innovative web portal for the school sector to support its users (mainly teachers) regarding the accessibility, production, use, reuse and adaptation of Open Educational Resources (OER) and to foster open best practices, regarding the exchange of knowledge and experience.

ISBN 978-615-5511-06-6

To set the scene for measuring ODS impact on national/regional curricula we first made a survey to depict the regulatory environment controlling the competence and content requirements embodied in the national/regional curricula of the specific country /region. The survey aimed at drawing the baseline", the situation in which the ODS initiative is embedded in.

The type of control structure in most of the countries is a multi-level pyramid structure, where the requirements set on the upper level are obligatory for the lower one. In the multi-level pyramid structure, if the school level curriculum exists, the school curriculum is part of the local pedagogic plan. The conditions for deviations from the upper-level control vary, but typically the national education rules, goals, and set quality standards should be met by the schools. How the schools meet these rules, goals and quality is decided by the schools themselves and the curriculum is fixed for the whole year. In summary, we can conclude that:

- national (or country) curricula exists in all countries responding;
- majority of countries use some form of a pyramid like control structure, in which the lower level should satisfy the requirements of the upper level, but might supplement it with additional content/requirements. In some countries the national curricula defines also the content and the textbooks to be used. If the curriculum is that detailed, the school has no flexibility at all, i.e. the school curricula is the same as the national/regional curricula;
- the 3 levels of the pyramid-like control structure are: national (controlled at government level), a medium level, controlled by a relevant education authority and a lower level, controlled by the school / municipality/ council;
- 77% of the respondents answered positively to the flexibility question. If the school curriculum is set at a lower level, the flexibility varies between 10 to 40 %, depending on the country and the subject. This gives space for innovative solutions in education;

Because of the pyramid-like multi-level curricula structure in the countries taking part in the ODS, we might say that:

- if the ODS resources used fit into the framework of the school curricula, they automatically fit into the national/regional curricula as well, and relevant to both of them;
- if the use of ODS resources are conform with the national/regional (n/r) curricula, ODS is relevant to the n/r curricula;
- ODS might influence the school level curriculum that is part of the pedagogic plan, without having any impact on the higher level n/r curricula;
- ODS might initiate changes in the n/r curricula, meaning that the use of these new resources is only allowed if the necessary amendments have been made on the n/r curricula.

Based on the information collected during the survey, the relevance of ODS to and impact on national/regional curricula can be classified as summarised in Table 1.

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Table 1: Four levels of relevance of ODS to and impact of ODS on n/r curricula

Level 0:	ODS resources are relevant and fully fit the local/school curricula (and automatically the national/regional curricula)
Level 1	OSD initiates changes in school curricula of certain subjects, but remains within the framework set by the n/r curricula of each subject (only if the school had some freedom to determine its own school curricula). The ODS material is relevant to the national/regional curricula, and has impact on school level.
Level 2	ODS initiates changes in certain competency areas or subjects (or the relative weight of the different competency areas or subjects) of the n/r curricula. Impact is observed at national/regional level
Level 3	ODS initiates coordination among different regions /countries at EU level to agree on a minimum set of requirements. ("Cross country impact")

These 4 levels indicate the penetration of ODS into the n/r curricula. The penetration starts from level 0 and as time passes and ODS use becomes widespread, level 1 can be reached. This can be expected in the most ambitious countries already within the timeframe of the ODS project. Attaining level 2 impact requires more time. Level 3 impact means that the educational authorities begin to harmonise the curricula in different countries. Since education is a national competence in the EU, such impact can hardly be expected in the near future.

Impact on Curricula

To create an appropriate methodology, we first defined the indicators in accordance with the results of the first survey on national/regional curricula structures, i.e. in harmony with the 4 levels of relevance of ODS to and impact of ODS on n/r curricula in Table 2.

Table 2: Impact indicators (Measuring the relevance to national/regional curricula)

- Agreement rate of participating countries with the statement that ODS completely fits the requirements and standards set in the local/school curricula (Relevance).
- Agreement rate of participating schools with the statement that enrichment activities provided by ODS enhanced the curriculum (initiated changes) at school level without conflicting with the national /regional curriculum subject-by-subjects (Level 1 impact, relevance to n/r curricula)
- Agreement rate of participating countries with the statement that experiences gathered by using the ODS platform initiated change requests in the curriculum at national /regional level (Level 2 impact)
- Level of cooperation among national curricula stakeholders across the EU (Level 3 impact)

To get quantitative results we divided the relevant stakeholders into groups of:

- teachers relatively new in using OER especially ODS resources ("newcomers")
- teachers experienced in using OER (especially ODS) resources
- other stakeholders
  - Group A: persons, whose profession is to influence the education system e.g. the curriculum designers, the policy makers; ministry experts;
  - Group B: persons, who participate in the education system without this professional influence. (Students, parents, and journalists etc.)

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The basic research tool was an online survey, containing the same questions for both the teachers relatively new in using ODS and for experienced teachers in using ODS. Different questions have been asked from group of the influencing professionals.

The questions for the 2 groups of teachers were as follows:

Table 3: Relevance and impact statements in the validation survey used in year III both for teachers new to the ODS and ODS experienced teachers

Q: *There were changes in my curricula due to the ODS resources from other regions/countries*
Answering options:
❑ *Changes in all curricula (both school and national).*
❑ *Changes only in the school's curriculum (level 1 impact)*
❑ *Changes only in national curriculum (level 2 impact)*
❑ *No changes in any curriculum (level 0, relevance).*
❑ *I do not know*
Q: *Some ODS resources gave me the feeling that our curriculum should be adapted (with options to agree, strongly agree, disagree, strongly disagree, etc.).*

Since the other stakeholders usually don't visit the ODS workshops in large numbers needed (for a valid statistical sample) for using a questionnaire, we interviewed some of them in person or in discussion with a group of these "other stakeholders", the results analysed and uploaded for further analysis and reporting. The aim was not to compare the various information received from these interviews or discussions but to collect new suggestions and exceptional ideas.

These interviews contained 2 curricula impact relates questions:

- Q1: If and which changes should result (or already have resulted) in the curriculum(s) (especially in the school curriculum), in teacher training, in infrastructure, administration and equipment.
- Q2: Do you feel that even the highest level curriculum needs to be modified (as a consequence of using ODS) e.g. with respect to teaching methods, use of e-learning methods, ratio of teaching hours with the teacher present to the time spent with independent work of the student?

A previous survey in year II already showed a strong relevance of ODS to (school) curricula (Fakhimi et al., 2014a; 2014b): its use improved the teaching practice, enabled the teachers to provide better learning experience to the students, had high added value, fit the local conditions and it was possible to integrate the ODS resources in the current curriculum. The majority acknowledged that ODS is aligned with their curricula and it had the potential to contribute to teaching and learning in future. Over 60% of teachers were positive

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(agree/strongly agree) toward the possibility of ODS integration with their current curricula and nearly 50% agreed that ODS resources fit their local conditions.

In year III during the validation phase of the ODS project the impact questions in Table 2 have been asked, and the survey gave the following results:

In answering the question about changes in the curriculum due to the use of ODS resources from other regions/countries, the majority (56.5%) of teachers new in ODS being "novices" in ODS use either did not know the answer, or skipped the question. 18.3% felt that the curricula remained unchanged despite using ODS resources from outside. (Relevance, Level 0 impact) Slightly fewer teachers observed a change in the school curricula (14.7%, Level 1 impact, relevance to n/r curricula), and even less, 10.8% stated that the n/r curriculum or both the school and the n/r curriculum was also changed in order to use downloaded ODS resources (Level 2 impact) at any curriculum level. This later is a typical scenario when the school curriculum is identical to the n/r one. These figures indicate strong relevance, somewhat weaker Level 1 impact and weak Level 2 impact. From the group of teachers experienced in ODS use about 40% felt relevance (no change in the curriculum, Level 0 impact), approximately 20% felt changes only in the school curricula (Level 1 impact), and about 10% felt Level 2 impact. This is a clear indication of the "penetration" of ODS in the curriculum. About 30% did not know the answer or just did not answer (see Figure. 1).

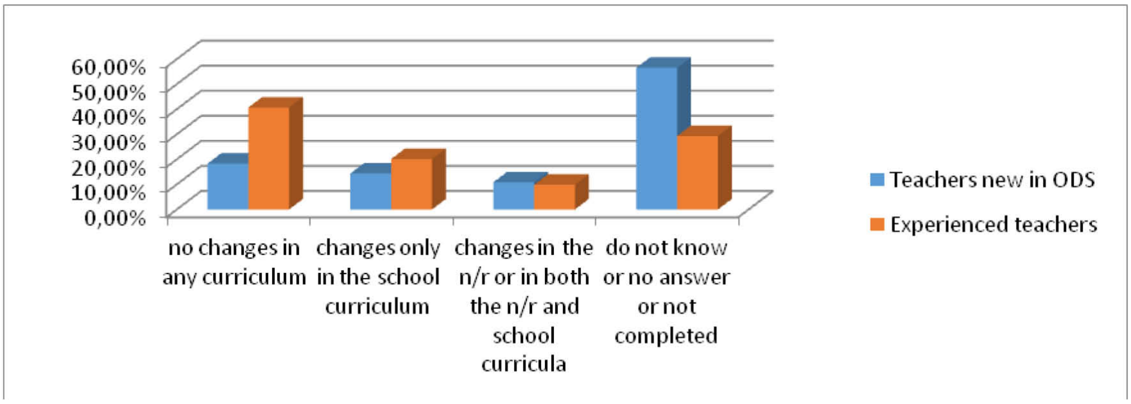

Figure 1. Changes in the curricula due to the ODS resources from other regions/countries

The answers to Questions **measuring whether they felt the necessity to update their curriculum** only about 44% of the teachers new in ODS use could form a definite opinion: agree, strongly agree, disagree or strongly disagree. Taking into account that they were the teachers new in ODS use, this is not surprising. In this group, the number of teachers agreeing with the need for changes in the curriculum was 34.7%, which is 3.5 times higher than the opposite (9.62%). Again, this indicates a strong impact of ODS on shaping the curricula. It is also worth noting that the need for changing the curricula is 10% higher than the percentage of answers stating that changes already happened.

Among the group of **experienced teachers** one-third did not answer the question about the need to change the curricula (significantly less than among the group of "novice" teachers where this figure was 55%), and from the remaining two third the number of teachers feeling

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the need for changing the curriculum was 10 times higher than the number of teachers disagreeing with this need. The ratio of teachers feeling the need for curriculum changes is about twice as high in the group of experienced teachers. These results are illustrated in Figure. 2.

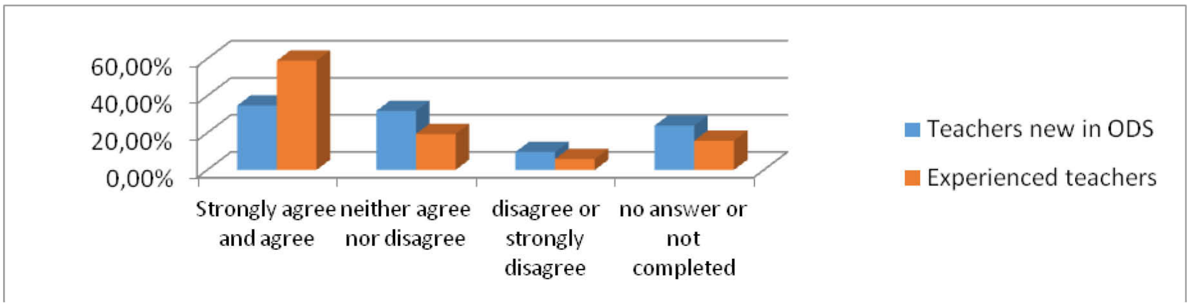

Figure 2. Agreement rate with the statement that some ODS resources gave the feeling that the curriculum should be adapted.

This impact slowly reaches the higher ranks of education providers, the school principals, headmasters and school directors. This is reflected in their opinion whether the use of ODS resources were in line with the proposed educational reform in their country. The analysis of the answers given to this question showed the following picture: The majority of them, nearly 62% agreed or strongly agreed that the ODS use is in line with the projected educational reforms of the respective country/region, and only about 4% were on the opposite opinion. If we disregard those that were undecided and the ones who failed to give an answer, about 94% of the answers supported the view that ODS is in line with their proposed educational reform. This is illustrated in Figure 3 and indicates a clear indication of a future strong impact of ODS a shaping the curriculum.

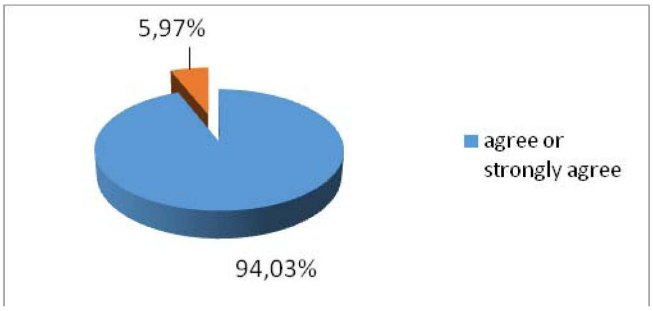

Figure 3. Agreement rate of school principals and headmasters who formed a definite opinion whether ODS is in line with the proposed educational reform of their country.

Impact on Schools (School metrics/school e-maturity questionnaire)

A crucial tool for assessing the digital maturity or e-maturity of a school is a school self-evaluation survey, based on the work done by the 'Digital Schools Program' (2014) in Ireland. The first sample of schools attempting a repeat of e-maturity questionnaire (http://e-mature.ea.gr) in order to assess any change/impact consists of 203 schools. Overall, results from all repeated e-maturity questionnaires indicate an increase of 5.69% in the digital maturity of schools after participation in and implementation of the proposed activities, which is deemed to be significant, given the short period of the pilot activity implementation of about one school year. Figure 4 shows a comparison between initial completion (phase A) and repeat scores. The categories in which a more significant increase is demonstrated in the e-maturity of a school are "ICT in the Curriculum" (7.57%) and "ICT Culture" (7.28%). As far as "ICT Culture" is concerned, the innovation model and the ODS communities have been designed with the aim to increase awareness on the role and integration of ICT in education. The increase in this category is an indication that the innovation model, as well as the CoPs have had a significant positive impact.

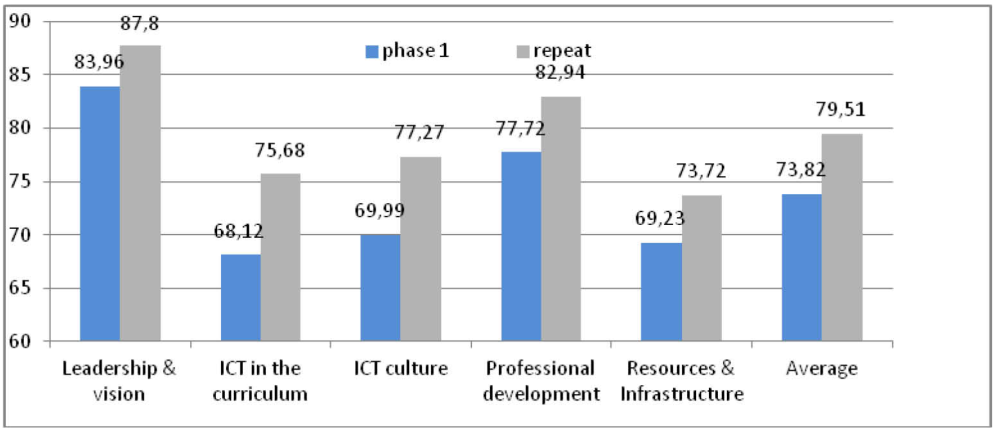

Figure 4. Mapping the change in schools performance: Phase1 vs. Repeat e-maturity scores (Chelioti et al., 2014)

Moreover, in order to measure the impact of the ODS in engaged teachers and schools and in order to record the obstacles and factors in terms of leading change in schools 38 workshops took place in 19 European countries and concludes to a set of recommendations on the first indications of the gradual change processes brought about in pilot schools. The three foremost identified obstacles to change across countries are the lack of infrastructure, lack of quality resources (educational scenarios) and teachers' lack of time or possible conflict of the intervention with the curriculum. The latter is associated with issues and levels of school autonomy. There were different perceptions of the role and links with national policies among more and less centralised school systems (e.g. UK-Greece). For countries with smaller degrees of school autonomy, based on the OECD (2010) report, there seems to be a greater need for increasing autonomy in order to foster change. On the other hand, in countries with a larger degree of school autonomy, it was identified that sustainable change should be linked to the National Curriculum (UK). There is a sense, thus, that although it is understandable by the teachers that any type of school innovation should not be imposed, rather be based on teachers' initiatives and experiences, the support and official recognition from National Agencies/Ministries still plays an important role for them. This, therefore, validates the ODS innovation model, in terms of combining top-to-bottom and bottom-to-top practices.

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Impact on Educational Systems

The following Impact Indicators on Educational Systems (Table 4) were defined:

Table 4: Impact indicators on Educational systems

Impact indicators (Measuring the impact on educational systems)
- Rate of application of digital devices has been increased in the school
- Rate of admission to higher education
- Rank of the portal (Google rank, Global rank using search engines optimisation tools)
- Rate of students obtaining more than schools' average exam score in last year subject by subject
- Rate of improvements in school's performance based on previous impact assessment results
- Rate of students obtaining a minimum K12/ secondary school qualification.
- Rate of outcomes emerging from the influence of ODS portal on the school's strategic decision makings.
- Rate of school's targets achieved being significantly influenced by using ODS

Two types of interview were used, one for Group A stakeholders (influencing professionals), and one for Group B (others), as described above, parallel with the harmonized set of questions with the same stakeholders as described in the curricula issues), and one short questionnaire was designed near the end of the project, concerning exclusively the impacts of ODS on the Educational Systems.

The analysis showed, that on the one hand the ODS could have an impact on each country's educational system if it had been officially integrated into this. On the other hand it has an impact on the educational systems since most of the educational stakeholders of the 21 participated countries, admitted that the ODS initiative includes all the elements for great effects to innovate teaching and learning in their countries. Both of these views have been extracted from the current research data. For example, a policymaker mentioned that "this would be the most profitable investment in terms of resources, provided that various categories of stakeholders would be trained to fully engage with ODS and exploit the new opportunities" (PM.SQ. Romania). Regrettably, it is fact that there is a lack of institutional compromises and constraints for providing the necessary support to educators to find and select new and free educational resources on their own, believing that it is too time-consuming (Richter et al., 2014).

Teachers face a lot of difficulties integrating innovative initiatives and approaches like ODS, into their school's environment, and their daily practices. The most frequent answer that create barrier is that the "system" itself is conservative in a lot of countries with close contexts and curricula that have to be followed, without the flexibility to adapt new innovative practices. Furthermore, the economic crisis worsened the school's possibilities concerning the needed quality infrastructure, lack of continuing official teachers training in Technology Enhanced Learning tools, practices, and methods.

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Figure 5. Difficulties that educational stakeholders face for ODS integration to the educational system, within "Wordle" cloud words

In relation to statements that ODS has already an impact on the educational systems, that have succeeded to incorporate it to their educational system either from different roadmaps totally (like Portugal and Greece), or partially as pilot trials to their schools. New categories emerged from educational stakeholders' answers, in relation to the ODS impact to the educational system comprised achievements of excellence in the fields of collaboration among communities of learners; enrichments of national/ regional curricula; new and multiple teaching methodologies; innovative ideas and activities; good practices in Science Education; enrichment of Open Education Resources (OER), online repositories; e-portals and digital resources; teachers' professional development; and the implementation of several school activities and ODS adaptability to different scenarios.

Most of the educational stakeholders recognize that "there is a need of National Strategy incorporating innovative programs to each country's educational system, as an operationalization of the EU Digital Agenda at national level "(PM. SQ. Romania)." We highlight some of the recommendations such as strategic planning for acceptance of innovation; teacher training; professional development; sustainable innovative development; transformation of schools organizational models; curriculum reconstruction, OER reusable, renewal, multilingual versions and integrating ethical values, etc. Some of their recommendations that concern the educational system are demonstrated in Figure 6.

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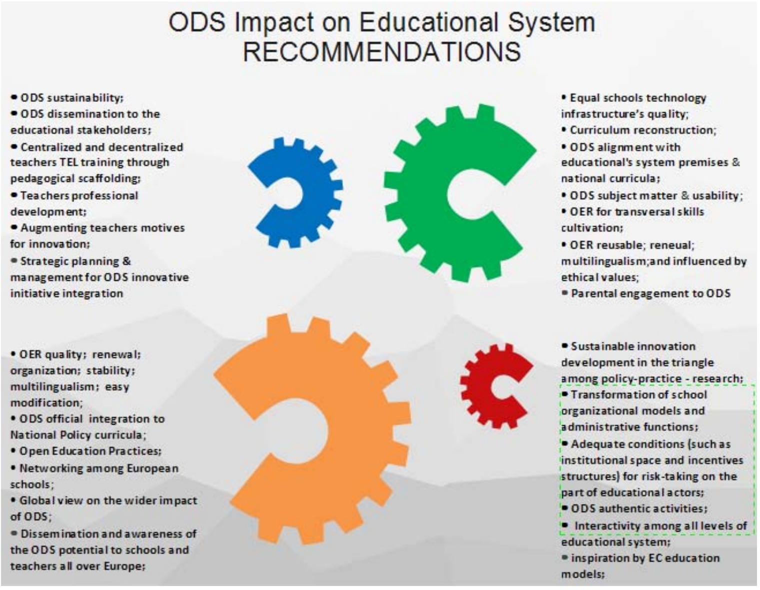

Figure 6. Recommendation for ODS Impact to Educational System with "Edraw" mind mapping tool

Conclusion

As far as the ODS Impact on curricula is concerned, we can conclude that the use of ODS resources proved to be relevant to the curricula on school as well as on n/r level. Based on the survey on curricula structure in the different countries, 4 relevance/impact levels have been defined, characterising the penetration of ODS into the school practice. Relevance of ODS (level 0 impact) meaning that the use of ODS fit into the school as well as into the national / regional curriculum without any changes in the curriculum is quite strong, the need for adapting the school curriculum to embrace more widespread ODS use is slightly weaker, and the need to change even the national/regional curricula is even less observable. According to the teachers experienced in using ODS resources, the ratio of first 3 impact levels is about 40:20:10. It is also very positive, that about 94% of the influencing professionals able to form a definite opinion on the question agreed that ODS use is in line with the curriculum development of their country. Level 3 impact could have been detected during the personal interviews and focus group discussions with influencing professionals (Group A), but perhaps because of the country competence of education in the EU, this was not observable. Regarding data the collected from schools there is an obvious link between the ODS communities and the various ODS-supported activities and changes regarding the "ICT awareness and "ICT Culture", since schools are offered an array of options and tools that may be incorporated into the teaching of all related subjects. These conclusions are in line with our expectations.

We believe that for all these suggestions not to be just a vision but a practical reality, administrative innovation comprising experimentation with and transformation of school organizational models and administrative functions, policies, and incentive structures, and professional development and training must take place. Instructional innovation denotes experimentation with and the transformation of pedagogical practices, curricular approaches, student assessments and professional collaboration is absolutely necessary. Both the present research evidences as well as to the study of literature proved that ODS is an innovative approach with a great potential of impact on the educational systems provided that it is fully integrated and implemented to the country's educational system used by communities of learners and school leaders.

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Acknowledgment

The part of this work is supported by Open Discovery Space (ODS).The ODS addresses the challenge of modernising school education by engaging teachers, students, parents and policymakers in a first of its kind effort to create a pan-European e-learning environment to promote more flexible and creative ways of learning by improving the way educational content is produced, accessed, and used. The full title of this project, funded by the European Commission's CIP-ICT-PSP-2011-5 programme, Theme 2: Digital Content, Objective 2.4: e-learning Objective 2.4, is "Open Discovery Space: A socially-powered and multilingual open learning infrastructure to boost the adoption of e-learning resources". The project started in April 2012 for 42 months, engages more than 50 partners all over Europe, and lasts for 42 months.

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

LEARNING ASSESSMENT AND SUSTAINABLE BUSINESS MODELS FOR OER INITIATIVES

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Abstract

This paper discusses the challenges and sustainable business models for e-learning portals, Open Educational Resources, processes and tools in order to achieve its primary aims and be emancipated from the boundaries of a classroom, a school, a geographic region, a country or even at Global level. Towards this direction this paper analyses the feedback and evidence collected through multiple workshops and surveys taking place in the context of the European Initiative Open Discovery Space regarding the learning assessment and sustainability of e-learning portals / tools and Open Educational Resources. This paper finally presents the ODS sustainability recommendations in the form of general guidelines to be followed by future initiatives.

Key words: sustainable strategies, challenges for OER initiatives, business models

Introduction

Modern education and today's learners' experiences are characterized by continuous and open flow of information and proliferation of technology, tools and learning processes, which enables learners to use, share, communicate, collaborate and focus on their main learning interest developing their skill in a fast pace. In this way, learners actively contribute to the creation of a user-driven "connected world" that is not restricted by the physical boundaries of a classroom or a specific geographic region (European Commission, 2010).

Open Discovery Space (ODS) is a European initiative (Athanasiadis et al., 2014), co-funded by the ICT Policy Support Program, spreading in 25 European countries during 2012-2015. It specifically addresses the challenge of modernising school education by implementing a pull rather than a push approach. It engages teachers, students, parents and policymakers in a first-of-its-kind effort to create a pan-European multilingual eLearning and community-oriented social platform (http://portal.opendiscoveryspace.eu). ODS is used as a case study and data provider regarding this study about the best sustainability approaches for e-learning portals, tools, content and material enables teachers to adapt learning material, resources, scenarios, tools, technologies, and software to individual students' learning needs.

In background knowledge, it is argued that sustainable development is an inherent concept that requires continuous assessment offering the opportunity for reflection and decision making for long-term innovation and sustainability (Rene & Pim, 2007). A successful sustainability and exploitation strategy is based on a successful business model that according to Johnson et al. (2008) must be founded around four pillars:

- Value proposition,
- Key resources,
- Key processes,
- Sustainable revenue stream or financial sustainability.

Following this general but well-established approach it can be argued that a successful sustainability strategy for an e-Learning portal/tool or OER must take into consideration the learner's needs and requirements in the continuously involving educational field and as well the other main pillars of a successful business model, analysed in the following sections.

Value Proposition

Any initiative, destined for profit generation or adopting a non-profit scheme, must offer a substantial value to its customers/stakeholders addressing their needs and requirements in a higher level than the competitors, offering innovative solutions to problems and a great range of high quality services (Johnson et al., 2008). As Kaplan and Norton (2004) emphasize that "Strategy is based on a differentiated customer value proposition. Satisfying customers is the source of sustainable value creation." Moreover, Rackham and Vincentis (1999) state that a successful and alluring value proposition must include convincing arguments, facts and data regarding:

- The capability of an organization/initiative to deliver the final product/service/tool;
- The estimation of the impact that this product/service/tool will have on the customers/stakeholders activities;
- The proof of concept;
- The cost estimation.

Following these arguments, the e-learning application value proposition must "convince" the key stakeholders involved in the educational process that the new initiative will address in a higher grade their needs and requirements as compared to the existing solutions presenting the impact of the e-learning initiative's offering.

Key resources and processes

The main focus of e-learning initiatives, portals and tools regarding the key resources and processes should be to investigate how the key resources interact and are combined in order to offer the greater value possible to the key stakeholders involved.

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Revenue Stream

The revenue streams define how the organization/initiative generates its revenue either it is a for-profit or non-for- profit organization/initiative (Johnson et al., 2008) taking into account the cost of the key resources and key processes. This is very important for the financial sustainability of initiatives in the field of elearning.

During the pilot implementation process of the ODS social innovation portal a numbers of workshops, surveys took place in order to identify important aspects, such as key stakeholder's needs and potential threats, before forming an attractive value proposition. The outcomes are presented in the following sections.

Identifying key stakeholder's needs and requirements through learning assessment

Under the umbrella of the EDEN 2014 conference in Zagreb, and in the context of ODS a workshop was organised entitled: "Learning Analytics for measuring and delivering impact in Education and Training" bringing participants and stakeholders together aiming to:

- discuss the education/training needs/expectations and potential benefits from the incorporation of harvesting learning analytics in e-learning tools and portals;
- explore innovative methods of learning analytics - particularly those which are suitable for the education/training environment;
- identify existing barriers and challenges in the use of learning analytics, and ways to address them;
- discuss the potential impact of such technologies on education at various levels (learner, teacher, class, educational system, policymaker, trainers) and how they can be used to evaluate the effectiveness of interventions in the educational/training/learning process.

The workshop was organised in two main parts. The first part comprised of two presentations: one introductory to the Learning Analytics scheme and one regarding the initial learning analytics harvesting and analysis in the context of ODS portal while the second part was an interactive discussion with the participants. This session was facilitated by a panel of members of the project consortium. Twenty-four (24) participants identified the need for more intelligent testing of the raw data that are harvested from the ODS portal with the use of a combination of analytics/big data and more conventional forms of data gathering such as surveys and questionnaires. In addition, the need for more meaningful ways to analyse the quantity of learning analytics data produced from the portal avoiding the extraction of false interpretations of the analysis' results was pinpointed as a vital aspect. Moreover, it was suggested that these interventions in combination with Learning Analytics can have impact on and lead to:

- the collection of real time data to assess the behaviour of the learners;
- the assessment of the level, skills and interests of the users;
- the assessment of the attitude of the users towards learning activities;

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- the formation of better key performance indicators for the educational processes;
- the assessment of the learning material and activities based on users' behaviour;
- the broader change in pedagogy policies and best practices;
- the broader evolution of the current educational curricula.

Furthermore, the participants suggested that there should be established ways/processes so that the harvested analytics to be used to help teachers extract useful conclusions for their own training. The teachers and tutors require updated material, resources and knowledge to train and further develop their skills which they consider are the most important aspect that an e-learning tool or portal should offer to them.

The latest workshop was organised in Brussels in May 2015 where more than 30 participants/education stakeholders unanimously agreed that:

- The incorporation of digital technology tools and innovative practices will have a great positive impact on education.
- The incorporation of digital technologies will add value to teaching and learning communities motivating them to evolve and change in their creative, reflective characteristics becoming more open and collaborative.
- Digital technologies offer opportunities to all education stakeholders urging them to adopt new and more effective best practices.
- The participant will support initiatives like ODS for the modernisation of the educational process.

Moreover, the participants expressed their wishes/opinions for the improvement of the ODS social innovation portal. More specifically, they suggested that ODS consortium should:

- incorporate a variety of resources repositories in cooperation with publishers and content providers;
- incorporate social network aspects and functionality;
- engage policymakers;
- work in close cooperation with teachers;
- offer "teachers-training" services;
- offer functionality for co-creation of innovative teaching resources material, tools, scenarios and practices;
- expand the projects activities to underdeveloped countries/regions;
- support community building functionalities.

Identifying Threats and Weaknesses

This aspect was the external environment "threats" in combination with the weaknesses of the ODS initiative.

The participants in these series of surveys stated that there are four main axons of challenges which are:

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- Teacher training: Teacher training is an essential element of education reform; particularly training that focuses on classroom innovative teaching and learning practices and engages teachers in an active community of best practices development. Teachers are also looking for content, scenario, lesson plans, authoring or editing tools to design their own courses or for web-based content to be used directly during their courses. In many cases teachers need awareness and training to use the tools, scenarios and lesson plans.
- Technical support: Teachers need ongoing technical assistance not only in early phases of ICT use but also during the whole process of the development of hardware, software and networking technologies that are more sophisticated creating more complex educational applications. Some of the European countries lack ICT infrastructure, and every school or class is not connected /equipped with new digital learning technology across the Europe (European Commission, 2010).
- Content development and alignment with the individual curricula: Since every country (throughout Europe but also around the world, follows a unique educational curriculum due to differences in culture and language, ODS should focus on the development of digital content tailored to their individual operational policy. Educational material, content, tools and resources need to be updated, translated, reformed and improved continuously, based on the results emerging from the impact assessment analysis. Material uploaded on the portal to be in a standardised format following specific educational and publication standards
- Operational costs and further development: There are always financial aspects involved for the development, operation, maintenance and improvement of the resources and portals. Elearning initiatives like ODS should look various options for financial sustainability.

Moreover, participants in the series of surveys taking place in the context of ODS identified and suggested that:

- initiatives like ODS should consider the variation in curricula that exist in different European countries;
- need to compete the resources quality of other competitors as well as the functionality of other well-established social media;
- require continuously updated material and a user-friendly registration process and an advanced search mechanism to spot these resources in need;
- a key-stakeholder engagement strategy is a vital;
- the platform needs to be more responsive;
- lack of motivation of teachers is an obstacle in accessing the project information;
- there should be a wider spectrum of events and services ODS provides.

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Addressing the sustainability challenges

ODS as any other initiative in order to surpass the aforementioned sustainability challenges was required to take into serious consideration the opinion and suggestions of its key stakeholders and target audience. The participants in the feedback events, workshop and surveys, characterised the e-learning portal market as a "red ocean" where the initiative should compete in an existing highly contended market requiring to beat competition and exploit existing demand differentiating from completion rather than creating new demand (Blue Ocean Strategy, 2015). ODS in order to surpass completion and secure its sustainability in the "arena" of e-learning portals developed a twin strategy aiming in to two directions:

1. to offer unique services differentiating from competition focusing on collaboration, co-creation, virtual environments in combination with state-of-the-art social media factions and covering the huge demand for training on best-practices "from teachers to teachers";
2. focusing on offer better quality on the services that both ODS and competition provide, offering a huge database of repositories, resources and material, easily accessible and a vast number of schools and teachers comprise the ODS community.

Forming the value proposition

ODS is focusing on school leaders, instructional leaders and innovative teachers. Exploiting the Open Discovery Space Innovation model and Tool Kit (a series of guidelines, scenarios of practice, tools and case studies from the numerous ODS schools) the programme can support participants to introduce innovative aspects in their school settings for the modernization and better cost efficiency of education process. This exploitation/sustainability plan is based on the idea that the ODS consortium will offer training courses to the school leaders through their schools, which will be attractive through appropriate accreditation. Additionally, ODS will offer other core ODS services and tools to supplement and enhance the sustainability focusing more on the end users to exploit the capabilities of these products. The Community of the schools /teachers are attending the training events that the ODS consortium provides through ODS Academy in the context of five days Summer School events taking place annually from 2013 and onwards.

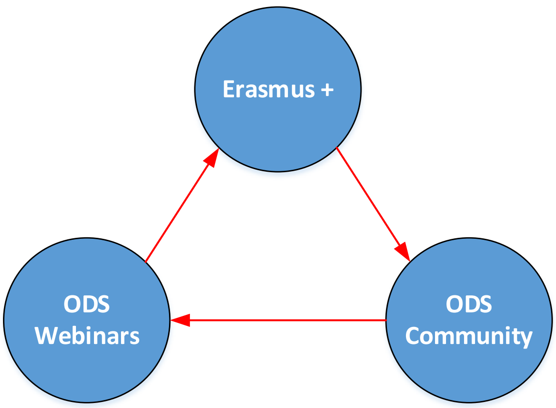

Figure 1. Training Academy Cycle

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As the ODS community will provide to and share through the portal learning material/scenarios and best practice activities the ODS consortium can utilise this to create the training material, and resources for the Academy events creating a product from the community for the community. This action will result in a reusability of the community material flowing through the portal to create training material according to the current trends and needs of the educational community. The training material will be the result of activities similar to the exploitation of economies of scale so it will have very low cost concerning its preparation but will offer great intangible value to the educational community.

The core product in this proposition will be the ODS Academies, the ultimate goal of the ODS Training Academy is to shape innovation leaders who will promote the uptake of e-Content in schools. It delivers training programmes and online support specially targeted for a set of stakeholders' key to the uptake of eContent. Its main goals are:

- to design training frameworks for ODS Academies translating the pedagogical requirements from Communities of Practice;
- to provide Educational Design and Scenarios of Use through specialised training programmes;
- to create and maintain an Online Training Academy within ODS to support and sustain the work of the Training Academies.

Four Training Academies are planned for a preliminary set of stakeholders:

- The Teacher Training and ICT Support Programme for Schools assist teachers in acquiring and reinforcing the skills and knowledge they need in order to exploit the rich potential of e-Content. Teachers will learn how to incorporate e-learning in their courses, to reuse and create e-Content. It will train ICT support staff and administrators in schools to support teachers and students working with e-Content and to implement local eContent repositories, linking them to the Open Discovery Space.
- The Technology Developers Programme provides theoretical and practical training (i.e. fast-track coding and interoperability exercises) to developers in content use (packaging formats, access control, and licensing) and content discovery (metadata, vocabularies, protocols, and registries). Developers will federate learning resources and incorporate them in the Open Discovery Space.
- The Content Providers Training Programme offers guidelines and support to content providers to adopt learning technology specifications, standards, and tools in view of sharing their content with the e-learning community, more especially through the Open Discovery Space.
- The eParents Training Programme is designed for parents who wish to gain insight into e-learning and work with e-Content to support their children's learning. Training is designed to inspire parents to become promoters and evangelists in the uptake, sharing, use and reuse of digital learning resources in schools.

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Concluding Remarks

This paper suggests that a sustainable e-learning initiative should follow a competitive value proposition that will aim to cover the challenges, needs, and requirements of its target stakeholders. Our findings indicate that the educational community has started to place more emphasis not only on sharing but also on the collaboration and co-creation of knowledge as well as to the training of the educators expressing ideas for a "teacher-for-teachers" scheme.

ODS as any other initiative in order to ensure its sustainability and long-term exploitation of its outcomes already considered and should continue taking into account the requirement offering innovative social collaboration tools, learning analytics, a well-established training program with material and best practices from the teaching community to the teaching community setting educators in the driving seat towards the development of the 21st century skills.

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Acknowledgment

This research has been undertaken under the Open Discovery Space project CIP-ICT-PSP-2011-5 programme, Theme 2: Digital Content, Objective 2.4: e-learning Objective 2.4, is "Open Discovery Space: A socially-powered and multilingual open learning infrastructure to boost the adoption of e-learning resources", funded with support from the EC.

ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

ACCEPTABILITY OF SOCIAL OER ENVIRONMENTS IN EUROPEAN SCHOOLS

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Motivational issues to Engaging in Social OER Environments

The educational domain is under constant pressure to make more efficient and effective use of Information and Communication Technologies (ICT). There has been a strong need to increase the abilities of school teachers as users of ICT but even more importantly, as educators of ICT use to their pupils (Wastiau et al., 2013). One of the great advantages and at the same time, one of the issues to improve has been seen in using ICT for sharing and using pre-existing content (Atkins et al., 2007). It has become a common practice in schools and academia to provide educational materials as openly licensed and free for others to apply and re-use. Around these collections of shared resources, various portals and services have been created to support active knowledge sharing and community building of educators to increase educational openness and discussion (Ha et al., 2011; Sotiriou et al., 2013), here referred to as "Social OER Environments".

Barriers or challenges to OER have received more attention in the recent literature. These issues have been discussed from the point of view of a teacher, organization/institution such as a school, ranging from interpersonal and to social and cultural issues that disrupt or keep people from using OER (Chen, 2010; Yuan et al., 2008; D'Antoni, 2008). Existing studies on OER often concentrate on ways of improving stakeholder engagement and active participation (Ochoa & Duval, 2009) in available OER environments (Richter & Ehlers, 2011). Therefore, it is vital to investigate the experience and maturity levels of schools, as well as individual teachers' experience in OER & ICT to understand how to overcome motivational issues regarding engagement to social OER environments. For this purpose, we propose a new explanatory model extending influence factors of technology acceptance with the new constructs of Schools OER maturity and Teachers' experience in OER and ICT.

Theoretical Model to Explain Increased Motivation

Motivation to engage in social OER environments combines the user's decision to share his knowledge socially, as well as the decision to use social OER environments. From the point of view of technology acceptance, the intention to behave is a main predictor of the behaviour (Davis, 1985; Davis, 1989). As influence factors which aim directly on the use of technology, we include perceived usefulness and ease of use to this study. Perceived usefulness is "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989). Perceived ease of use represents "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989). Both crucial predictors of technology acceptance have been repeatedly validated (Lee et al., 2003; Venkatesh & Bala, 2008). Therefore, our hypothesis adapted from the technology acceptance model (TAM) by Davis (1989) state that:

- H1: Perceived usefulness positively influences the motivation to engage in social OER environments;
- H2: Perceived ease of use positively influences the motivation to engage in social OER environments;
- H3: Perceived ease of use positively influences the perceived usefulness of social OER environments.

Several educational difficulties exist at the European level. Europe is falling behind in the digital sphere; the great majority of schools are not digitally equipped and their students are not taught by digitally confident teachers, rather teachers who mainly use ICT to prepare their teaching but not as a skill for students to develop in the classroom (Wastiau et al., 2013). Most teachers at school level do not consider themselves as 'digitally confident' or able to teach digital skills effectively (Survey in Schools, 2013). Previous studies seem to highlight the key challenges of schools' OER maturity around teachers' acceptance of OER and services (Atkins et al., 2007). The main facilitator being how the schools as organizations support ICT based learning (Humbert et al., 2008). Another key facilitator of engagement seems to be creation of common practices (Chen, 2010). The existing infrastructure (Pirkkalainen, Jokinen & Pawlowski, 2014; Richter & Ehlers, 2011) is also in a big role when facilitating the teacher's acceptance of OER. In this study, we combined those key concepts into "School's OER maturity" which indicates the level in which schools use OER and open practices. Our hypotheses based on previous studies (Wastiau et al., 2013) in the field are:

- H4: School OER maturity positively influences the motivation to engage in social OER environments;
- H5: School OER maturity positively influences the perceived usefulness of social OER environments;
- H6: School OER maturity positively influences the perceived ease of use of social OER environments.

Hatakka (2009) underlined the teacher's problems in finding suitable resources for their context as well as the difficulties in adapting digital educational resources for their own teaching needs. A vital barrier also seems to be the teachers' experience in working collaboratively (Martinez, 2010). We combined these three aspects into a new construct 'Experience in ICT and OER'. In this paper we were interested the following hypotheses based on the teachers' experience in ICT and OER:

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- H7: Experience in ICT and OER positively influences the motivation to engage in social OER environments;
- H8: Experience in ICT and OER positively influences the perceived usefulness of social OER environments;
- H9: Experience in ICT and OER positively influences the perceived ease of use of social OER environments.

This paper presents the key influencing factors to increased motivation of teachers to engage in social OER environments.

Methodology

This study focused on teachers in primary and secondary schools in Europe. The data collection was conducted within the EU-funded FP7 project "Open Discovery Space". A survey was used in Practice Reflection workshops to run a behavioural study. Altogether 444 valid responses were collected from teachers participating in altogether 76 workshops.

The model was tested using a single structural equation model (SEM), which had had 19 items and five latent factors, with AMOS software. The model adequacy was assessed with following indices and results:$\chi2/df$ = 2.91, CFI = 0. 95, TLI = 0.94, RMSEA [90% CI] = 0.066 [0.058, 0.073], RMR = .052, GFI = 0.91, and AGFI = 0.87. All indices met the desired criteria for a fit model. Assessments of internal consistency and convergent validity are displayed in Table 1.

Table 1: Internal consistency and convergent validity indices of the factors

Factor	Items	Alpha	CR	AVE
School OER maturity	4	0.82	0.82	0.54
Experience in ICT and OER	4	0.84	0.85	0.56
Perceived ease of use	3	0.90	0.90	0.75
Perceived usefulness	4	0.89	0.89	0.67
Motivation to engage	4	0.87	0.88	0.64
Note. N = 444. CR = convergent reliability. AVE = average variance extracted.				

Results and Discussion

A confirmatory study was set to identify what aspects increase the motivation of teachers to engage in social OER environments. The structural model and standardized regression weights are displayed in Figure 1. The explanatory power of the structural model is indicated with the R2 values of the dependent constructs (Wasko & Faraj, 2005). Chin (1998) denoted a substantial level (R2=0.67), a moderate level (R2=0.33) and a weak level (R2=0.19). The model R2 for motivation to engage was 0.74, which can be seen as substantial. The total effects of the factors on motivation to engage were experience = 0.37, organizational maturity = 0.05, perceived ease of use = 0.43, and perceived usefulness = 0.56.

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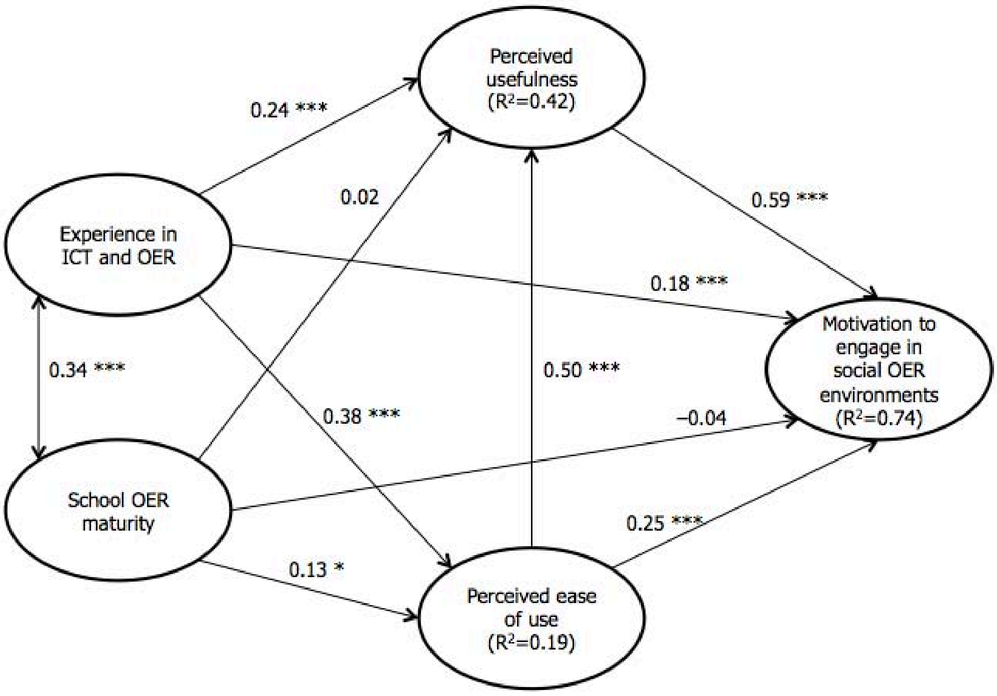

Figure 1. Research model for increased motivation to engage in social OER environments
N = 444. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Overall, all hypotheses were supported except for hypothesis H4 and H5 that suggest the positive influence of school OER maturity to motivation to engage as well as the perceived usefulness of social OER environments. Consistent with TAM, both perceived usefulness (0.59, $p < 0.001$) and perceived ease of use (0.25, $p < 0.001$) had a positive effect on motivation to engage in social OER environments. The effect of perceived usefulness can be argued to be close to substantial according to Chin (1998). The total effect of perceived ease of use to motivation was moderate (0.43), being close to substantial. As predicted by TAM, the positive effect of perceived ease of use to perceived usefulness was strong (0.50, $p < 0.001$).

As hypothesized, teacher's previous experience in ICT and OER had a positive effect on the motivation (0.18, $p < 0.001$). According to Chin (1998), the effect can be argued as weak. However, the total effect was a moderate 0.37. Additionally, the positive influence of previous experience was shown to perceived ease of use on a moderate level (0.38, $p < 0.001$) and on a weak level to perceived usefulness (0.24, $p < 0.001$). The results indicate that the school OER maturity does not have a positive effect on the motivation to engage in social OER environments (hypothesis H4 unsupported). Similarly, the positive effect of school OER maturity to perceived usefulness (H5) was not supported. However, school OER maturity did have a weak positive influence to perceived ease of use (0.13, $p = 0.023$).

The positive influence of personal experience in ICT and OER towards increased motivation could be expected. The EU is prioritizing the improvement of the quality of teacher education so as to have a direct effect upon levels of students' acquisition of competences. Therefore, the professional development of teachers and their training is a key requirement for the way forward (European Commission, 2010).

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The role of online teacher networks in further development of teachers should be emphasized on as well. Studies such as the ITCOLE project (Leinonen et al., 2001) show that sharing past experiences leads to innovative future practices and furthermore that community members were more likely to develop a more conscious involvement in the activity and create knowledge (Barwick et al., 2009). The online communities can be deployed to effectively support and nurture innovative teachers in schools across Europe. Innovative strategies will be strengthened within the CoP framework and promulgated amongst other teachers thereby increasing the effectiveness of the learning environment.

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

TOWARDS SUCCESSFUL PARTNERSHIPS BETWEEN SCHOOLS AND PARENTS: NEEDS ANALYSIS FINDINGS FROM THE E-STEP PROJECT

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Abstract

This paper reports on the needs collection and analysis findings of the E-STEP Comenius European Project, which set out to explore teachers' and parents' needs in terms of developing successful partnerships. The data were collected through a series of focus groups with teachers and parents, organised in Austria, Bulgaria, Greece, Ireland and the UK. More particularly, the study involved teachers' and parents' current experiences and attitudes towards parental engagement in schooling, as well as the skills and pre-requisites that could favour successful partnerships between families and schools. The analysis also addresses the use of social networking technologies for parents' and teachers' collaboration, along with the prevailing attitudes and skills towards the deployment of such media. The aim is to conclude to a set of requirements for the design of training programmes for teachers, but also for other interventions and projects with a similar interest in parents' engagement in schooling.

Introduction

Parent's participation and engagement in schooling has been found to have numerous benefits for pupils and schools. Research has shown that parental engagement can be powerful in improving pupils' cognitive and social development, as well as their learning outcomes (Howland et al., 2006) Effective school leadership is also associated with building active partnerships with parents, and this –in turn- has been found to encourage higher achievement levels and to support pupils' overall development (Official Journal of the European Union, 2009). There is also consensus that despite the varying types and degrees of parental engagement, it is associated with a range of positive indicators, including attainment (from early childhood until adolescence and even adulthood), school dropout reduction and fewer behaviour problems (DCSF, 2008; Stevenson & Baker, 1987) Partnerships between schools and families can also enhance social integration, i.e. for children with migrant backgrounds (European Commission, 2009).

In this light, E-STEP (http://estep-project.eu) project addresses schools' and parents' collaboration as a key factor for pupils' and schools' development. The project) specifically addresses school staff and intends to help teachers and school managers acquire and reinforce such attitudes, skills, knowledge and qualifications that will enable them to effectively engage parents in schooling and interact with them through social networking technologies. The goal is to design, implement and evaluate a training programme for teachers that will improve those skills.

In order to design the training programme, a needs analysis study was conducted, based on data collected in a series of focus- groups in 5 different countries (Austria, Bulgaria, Greece, Ireland and UK) involving teachers, parents and school staff.

Based on all these data, the needs analysis findings set of conclusions and recommendations in the final section for development of the training framework regarding the key areas: content, teachers' skills and attitudes that should be targeted, as well as technical facilities to be offered for development and implementation of teachers' and parents' interaction. Below the most important findings are presented

E-STEP workshops

Overall a total number of 12 workshops were organized in all 5 of the participating countries, with 78 participating parents and 104 members of school staff, including school principals, teachers and ICT teachers / learning support facilitators.

The focus group discussions covered the following points:

- Which **forms of collaboration/ parental engagement** had the workshop participants experienced?
- **How open were the participating parents** to collaborating/ engaging in schooling?
- **How open were the participating teachers** to collaborating/ engaging the parents in schooling?
- Which **different types or profiles of school staff** did you identify in the workshop in terms of **previous familiarity** with parental engagement?
- Which different types or profiles of school staff did you identify in the workshop in terms of current skills in communicating/ collaborating with parents?
- Which **different types or profiles of school staff** did you identify in the workshop in terms of **ICT skills**?
- Which **skills** were identified in the workshop as important for **school staff** in order to enable successful partnerships with parents?
- Which **conditions** were identified in the workshop as positive for using digital technologies and social networking tools for schools' and parents' collaboration?
- What **technical facilities** should these digital tools provide in order to foster successful partnerships with parents?

The following section consolidates the findings for each of these issues, as reported by the E-STEP partners. When referring to the country where each finding, observation or comment was reported, the reference emerges from a specific school setting or case of parental

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engagement in the specific workshop, and does not necessarily reflect a general practice in partner countries

Needs analysis findings

In terms of forms of teachers' – parents' collaboration / parental engagement previously experienced and the use of digital tools for it, the majority of teachers stated that they were highly experienced and familiar with some form of collaboration with parents. The ICT tools mentioned could be categorized in two groups: the first includes one-way ICT tools, addressed from the schools to the parent (i.e. regular text messages to parents, updates on the school website, newsletters to parents, e-mails to parents). The second seems to be more interactive, enabling parents not only to receive information on the child's academic performance or other school events/news of the school, but to also make their own contribution to the communication (e.g. e-mailing systems enabling the parents to book online appointments with teachers, e-diaries for two-way communication with parents and social media – less frequently and in specific school contexts). Overall, despite the general use of ICT, it seems that the importance of face-to-face contact was highly valued by both parents and teachers and there was a general reservation from both sides about the potential of digital tools, to substitute face-to-face contact. What is more, there was a mutually stated need to organise face-to-face meetings on a regular basis, including one-to-one sessions in schools where this did not yet happen.

The parents who participated in the focus- groups were reported to be more open to get involved in schools that had already established systematic practices, such as regular meetings with specific agendas and communication practices (e.g. pupils' diary in a school in the UK). In the Irish workshops it was also observed that parental involvement or engagement is associated with parents' expectations of the school and their own child in terms of achievement in academic subjects. Also, some parents clearly stated that they need clear guidance about how to help their child with homework, presumably reflecting the suggestion that parental enjoyment of homework activities increases with increased involvement (Luckin, 2006). As it was also expected, members of schools'- parents Boards / Associations were reported to be more open and motivated to get engaged (explicitly reported in one of the two focus-groups in Greece).

On the other hand, teachers' focus groups in general terms expressed a more positive attitude towards parents' involvement/ engagement compared to parents. This was clearly evident in the workshops conducted in the UK, Austria and Bulgaria where there was stated consensus among teachers on the importance of parental engagement. In other cases there were explicit reservations associated with: i) Financial issues/ economic crisis/ work overload that prevent teachers from being willing to exceed their official (and paid for) roles (Greece, Ireland). In one of the two Irish workshops, teachers explicitly noted significant variations in parental engagement and involvement, related to social class and educational attainment level of parents. A noted factor was the high proportion of families coming from migrant

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backgrounds and a new level of multilingualism which could affect communication, at least initially. Language issues were also mentioned as barriers that teachers face in practice when dealing with non-native speaking parents (e.g. from migrant backgrounds) as it was reported in the Greek and the British workshops, and intensive support was found to be important for teachers. ii) Power balance and teachers'- parents' roles, i.e. parental engagement was perceived as intervention to teachers' practices or each side tends to blame the other for being unable or unwilling to collaborate and communicate effectively. However, this openness to collaborate that was stated both by parents and teachers (to a greater extent in these focus groups) is not always applied in practice and there is a sense that each part tends to "accuse" the other of not being willing to collaborate. It thus becomes clear that parents' engagement is a two way process where power balance, authority issues and roles should be carefully addressed, in line also with Goodhall and Vorhaus's suggestion (2011) that local contexts need to be considered so that 'strategies accord with the interpretations and values of the parents they are aimed at'.

Another observation is that parents' engagement and the perceived need for it, both by parents and teachers, reduces as pupils grow older, as the workshop reports from the UK, Greece and Ireland clearly described. Reversely, resistance towards the use of social media for educational purposes and for engaging the parents seems to be more intense in Primary education, mainly due to privacy and security issues. Indeed these findings seem to validate various findings of the literature from the participating countries, (Chelioti et al., 2014a) where many differences were found between Primary and Secondary Education.

In terms of teachers' skills for successful collaboration with parents, communication skills were reported to be the top priority in all countries. This was also in line with our literature review finding from Austria, Bulgaria, Cyprus, Greece, Ireland and the UK; both in the studies where technology was used, as well as in the ones where collaboration with parents was implemented in more "traditional" ways, there was an emphasis on communicative and affective competences and skills, though of as important for teachers to engage the parents (Chelioti et al., 2014a).

The term 'communication skills', however, did not seem to be equally understood. Some of the terms met in the workshop reports that fall in this category are: 'interpersonal social skills' (Austria), 'negotiation- political skills' (UK), 'good listeners' (Ireland). Some teachers seem to perceive them in terms of the technical knowledge of using ICT tools to communicate, others understand them as the "political" skills to communicate a meaning to parents. Also, teachers' current skills to communicate and eventually collaborate with parents seem to be associated with the practices that they are mostly familiar with and the established patterns of communication with parents. In cases where there is no uniform strategy for engaging parents, it was not particularly clear whether teachers had developed specific skills. Apparently teachers seem to employ various methods of communication and thus skills depending on available the means and resources.

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It was also marked that teachers' skills and attitudes for effective parental engagement seem to be very closely linked. Training teachers on communication skills, that were reported as the number one factor, cannot be dissociated from supporting them to develop attitudes such as empathy for parents' perspectives, diversities, perceptions and own experiences from schooling. Similarly, their views seemed to be closely associated with the school policy, established practices for parental engagement and their role within those. ICT-related skills were less frequently reported as priority (mostly in the Bulgarian workshops), while evaluative skills were mentioned in one of the Greek workshops, as important for the teacher to be able to respond to challenges regarding reporting to the parent on the child's academic progress. Here again, this skill, as described, seems to be closely associated with how the result of the assessment is communicated to the parent.

Most of the conditions that the workshop participants considered important for schools' and parents' collaboration through social networking digital tools focused on technical facilities and infrastructure and security/ transparency issues. These concerned both schools and parents. Availability of resources, access to broadband and positive sense of security in using social media was unanimously mentioned as prerequisites. These were also associated with overcoming language barriers, especially for non-native language speaking parents, for whom the resources as well as any form of online communication should be facilitated, e.g. by efficient translation services. Training for teachers and also for parents in effectively and appropriately using ICT and social media was also reported as important. However, the use of social technology for schools' and families' interaction was also clearly bound on the existing school policy for parental engagement and the types of face-to-face interaction. This supports the assumption that social technologies or communication platforms build upon pre-existing school/parent relationships and activities or even provide a new site for the continuation of some existing tensions – particularly in the ways in which Learning Platforms served to support uni-directional communication and maintain strong borders between 'insiders' and 'outsiders' (Selwyn et al., 2011, p.321)

The security and transparency issues addressed mainly by parents in the workshops focused on the protection of information regarding their children's overall performance as well as personal information that might be exchanged with the teacher, e.g. privacy and security settings depending on the user, user- friendliness for parents (regardless of their digital literacy), immediacy, interactivity. Some participants in one Greek workshop actually stated their preference for using chat tools instead of platforms to communicate with the teacher, considering chat rooms as more private and closer to face-to-face communication. They also preferred to use platforms that have been set up for educational purposes, like Open Discovery Space http://portal.opendiscoveryspace.eu instead of Facebook.

In terms of using social media to interact with the parents, there were mixed views from both parents and teachers, with the exception of specific schools from the UK that were already implementing such practices. In general terms, reservations on the part of teachers were associated with the potentially uncontrolled access that such media can provide to parents

ISBN 978-615-5511-06-6

over teachers' work. Some teachers' views seemed actually to reflect what has been described as the need to reconsider how they publicly present their work and how it will be received by the parents (Selwyn et al., 2011, p.321). Also, it was observed that digital literacy experience/expertise influences teachers' understanding of social media and its potential use or benefit. Even in schools where ICT tools were quite widely used to communicate with parents, the phone was still considered to be as the most efficient means of communication. The phone, on the other hand, was perceived as a more intrusive means of communication, in different school contexts and suggestions were made that it should be used with caution.

Conclusion

This empirical qualitative study of 187 teachers' and parents' needs and perceptions yielded various forms and degrees of parental engagement, that seem to be determined both by national policies and definitions of parents' current or potential roles in schooling across countries, as well as by school-specific and social factors. The analysis showed that – with few exceptions- most teachers and parents have very little experience of collaborative parental engagement in non- face-to-face contexts, and face-to-face interaction is still highly valued by both sides, especially by parents. There seems thus to be a need for training teachers on efficient communication through ICT, i.e. on how the perceived positive aspects of 'traditional' communication (i.e. real life communication via phone or face-to-face) can be transferred to online communication. There is also a matter of a change in mind sets, both for teachers and parents: The use of social media should be viewed as an innovative practice that involves development of skills both for teachers and parents, instead of a replacement; on these grounds, as the analysis of these focus groups showed, it is most likely to work and on the condition that good face-to-face relations are already in place. Also, parents' openness to get actively engaged in schooling seems to be a two-way process that derives not only from their own interest and wish but is also fostered by school culture and policy. This should be viewed in conjunction with the view that any type of intervention or attempt for change in schools should be context- specific and addresses the school and wider social ethos and culture. All staff within a school, regardless of role, needs to become committed to a common definition of and vision for parental engagement and this seems to be a major pre-requisite for any type of training and practice.

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Acknowledgment

This survey consumed huge amount of work, research and dedication. Therefore we would like to extend our sincere gratitude to BCU members namely, Prof. Alex Kendal, Phil Taylor, Eleni Kanira for their important feedback as well the rest E-STEP consortium (http://www.estep-project.eu/?page_id=13).

The E-STEP project (539498-LLP-1-2013-1-GR-COMENIUS-CMP) has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

INTRODUCING PRE-SERVICE PRIMARY EDUCATION TEACHERS TO THE 21ST CENTURY SKILLS: CHANGING SCHOOLS AS LEARNING ORGANIZATIONS BY UTILISING DIGITAL GAMES

Margarida Romero, Université Laval, Canada, Niki Lambropoulos, London South Bank University, United Kingdom, Vaibhav Birwatkar, Yashwantrao Chavan Maharashtra Open University, India

Introduction

Primary education has not evolved significantly in the last decades. In fact, if one observes photos from 19th century and today's classrooms, differences one expects to see do not exist. School buildings, classroom organization, curriculum and teacher-pupils interactions have evolved far more slowly than other organizations in our society. Information and Communication Technologies (ICT) and societal challenges changed in a much rapid pace than most of the elementary school system. ICT opens new opportunities but also introduces new lifelong learning challenges to the 21st century children (Lambropoulos & Romero, 2015). In this study we analyze the 21st century skills and competencies developed by pre-service primary education teachers in Québec (Canada) through an activity aiming to make them develop the 21st century skills through the integration of digital games in the classroom.

21st century skills for primary education learners

Nowadays, a global human network is connected and mediated by new technologies (Castells, 2011). Such great network and the collaborative learning opportunities it offers have the potential to develop the skills and competencies within a lifelong learning perspective (Koper & Tattersall, 2004). The networked society empowers citizens of different age to regulate and develop their own lifelong learning process. The network has the potential to offer the continuous development of skills and competences so that we, as learners, can become the architects of our own knowledge and learning environments. New technologies enhanced our inter-dependency and common ground for sharing knowledge, skills and competencies. In the 21st century setting, learning, either onsite or online, occurs by containing different knowledge and skills acquisition levels by enabling members' engagement and practice. Consequently, the tools expand our perception and therefore, our education and research. They spread out from the individual, to the dyads and triads, to the small groups of 4-7 members, to bigger communities and social networks. The multilevel learning contexts from the individual learner to the social groups leads to a multidimensional construction of knowledge (Stahl, Cress, Law & Ludvigsen, 2014).

Such 'Net Human Intelligence' can be a learning target even as early as primary education; the students will graduate in a new an unpredictable world that needs to be redefined by them. As such, the 21st century skills (Griffin, McGaw & Care, 2012; Voogt & Roblin, 2012) comply a generic and innovative framework which is anchored in solid pedagogical design. The individuals acquire the knowledge, skills and competencies on creativity, organisation and project management in spiral and evolving scaffolding so to improve their inherent ability for adaptation. Hence, the 21st century skills enable the learners to deal with the ever-increasing complexity and are related to: focused and widened observation, information identification, information critique and synthesis, knowledge awareness in diverse contexts, critical thinking, connectedness, one and two ways of communication, presence and co-presence, self-reflection and meta-cognition, abstract and collective mind abilities, emotional intelligence and leadership, co-creativity and innovation and lastly, self and group organisation. Consequently, the proposed 21st Century skills and competencies matrix expands from the individual learner to the wider community and the world and summed up as represented in Figure 1.

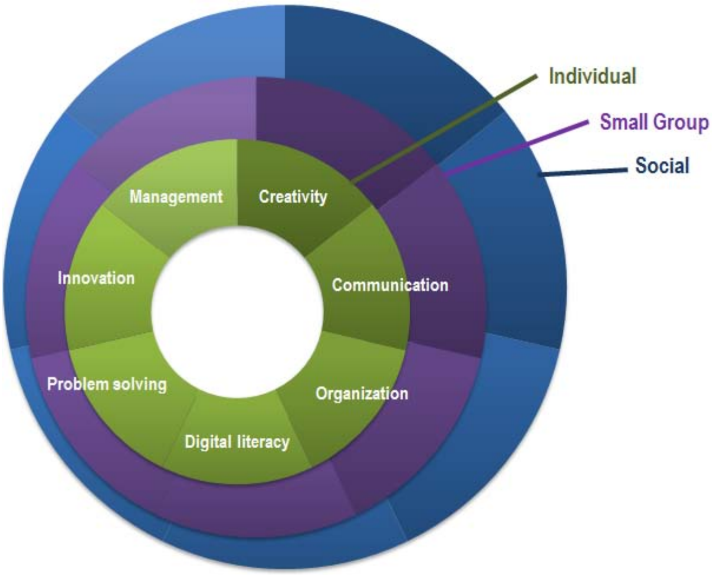

Figure 1. 21st Century skills from individual to social levels.

Primary education is nowadays challenged to introduce the 21st century skills within an already content-based curriculum and the country-specific 21st century skills frameworks. However, following the belief that anything can be taught in primary education as long as we invent the appropriate methods, and based on our previous experience with teaching advanced programming and quantum physics in 10 years old students (Lambropoulos & Romero, 2015), a case study was conducted with pre-service teachers in primary education in Université Laval. As the primary school students are keen on playing digital games, a decision was made to follow this line of research and associated pedagogical methodologies.

Using digital games for developing the 21st century skills

Games are a compelling activity providing a series of self-administered, level-based challenges, which are often self-regulated by the player. Games can help to develop the 21st century skills (Romero, Usart & Ott, 2015) in an environment of relative risk-free failure exerting a level of control of the game (McGonigal, 2011). Skill is the part of the competence related to the ability to behave effectively and engage certain attitudes and knowledge in action-oriented situations (Argyris & Schon, 1974). According to Prensky (2001), game is a form of "organized play", an activity, in which participants follow prescribed rules that differ from those of real life while striving to attain a challenging goal. Game-Based Learning (GBL) spectrum ranges from ad-hoc designed digital serious games which allies learning objectives in a game universe with a certain cognitive and visual immersion, and gameplay to gamification as the use of game design elements in non-game contexts. A digital GBL integration was introduced to this research case study for pre-service teachers on personal and group level.

DGBL integration: serious games, gamification, educationalization of entertainment games and digital game creation.

In this study, we introduce four forms of DGBL integration in education: i) using serious games, ii) educational gamification, iii) educationalization of entertainment games for educational purposes or iv) creating digital games as learning activities. For each of the DGBL strategy we introduce a description and the computer tools associated to it.

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Table 1:

DGBL integration	Description	Computer tools
Using serious games	Using a serious game in class means that the teacher brings into play a game that was primarily designed to meet educational purposes. The idea behind serious games is generally to provide a virtual environment for the learner to put into practice what he learned during class. Of course, it can also be used to learn new knowledge.	Serious Games are computer environments conceived for developing a certain amount of learning objectives; e.g. the serious game Café des Mathadores aims to develop the fraction concepts in Maths.
Educational gamification	Educational gamification can be described as the usage of game principles in a concrete educational context. In other words, the classroom is transformed into a game. For instance, the teacher could give quests instead of giving homework and those quests would give students rewards.	Gamification systems for education (ClassCraft, ClassDojo..) or general gamification systems that could be used for education (e.g. Badgeville).
Educationalization of entertainment games	Educationalization of entertainment games for educational purposes is very similar to the usage of serious games, since both of them employ digital games in order to reach one or many educational purposes. However, in this case, the game that is being used wasn't created as an educational game, but as an entertainment game. So, a teacher using a commercial game in class in order to meet specific learning objectives would be a good example of educationalization of entertaining games.	The use of any type of entertainment game as a context of object of study for a curricular objective; e.g. using the game Angry Birds in Maths for introducing the concept of parabolic trajectories.
Creating digital games as a learning activity	Creating digital games as a learning activity focuses on the process of game creation in order to reach the desired educational goal. Unlike in the other three forms of DGBL in which students are placed in the role of consumers, in that last form the students become creators. This means that the educational purposes are not met by playing the game, but rather in the process of creation itself. That last form of DGBL integration also requires a game creation software or application.	Digital game environments' such Scratch or game creation tools or engines based on visual programming such GameSalad.

Methodology

This section introduces the methodology developed for introducing pre-service teachers to DGBL integration in the curriculum. The pre-service teachers (n=73) were introduced to four strategies of DGBL integration in the classroom in two classes at the end of the course, once the students had developed their basic ICT competencies. In the first class of the DGBL activity, the professors facilitated an introduction to DGBL curriculum integration and provided one example for each of the strategies. The pre-service teachers were given 3 weeks to complete an activity inviting the students to choose a strategy for integrating DGBL in the primary education curriculum.

Participants

Participants are pre-service teacher in their third year (n=73) of the Bachelor's Degree in. Education and Primary Education program (BEPEP) at Université Laval (Québec). The participants were enrolled in the educational technology compulsory course of their bachelor's degree. The students' groups were organized in two groups of 58 students in Québec (50 female and 8 male) and 15 female students in Beauce.

DGBL Strategy Results

Figure 2 introduces the learning sequences produced by the students according to the DGBL strategy they decided to choose for integrating DGBL in the primary education curriculum.

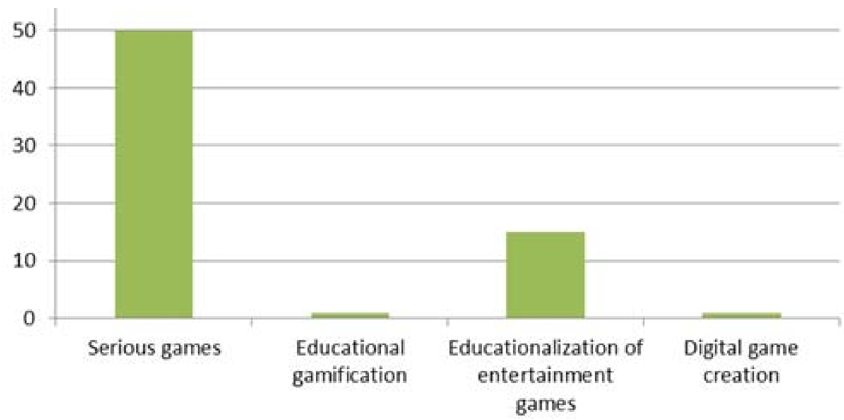

Figure 2. Strategies for integration DGBL in primary education curriculum

We observe that a majority of the students (n=50) decided to integrate serious games that have already been designed with educational purposes. For example, one of the students proposed to use a geometry game on an educational website (takatamuser.com). That game is meant to introduce students to geometry by having them replicate the geometric forms on a snake. In order to help the snake to retrieve his decorations (geometric forms) the student needs to identify them and give them to the student in the same order. Since this game was primarily designed to help students learn geometry it is a serious game.

The second strategy selected by the students is the educationalization of entertainment games (n=15) such as the use of *Candy Crusch*, *Boogle* or *Minecraft*. For instance, one of the subject proposed to use *Trivia Crack*, which is a an online game in which the players are paired up in a competition setting in order to answer to answer general knowledge questions. That game wasn't intended to be an educational game so it enters the educationalization of entertainment games category. That subject proposed for students to play against each other to get more

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acquainted with Trivia Crack and then use it to create their own questions to play against each other.

The use of digital game creation as a learning activity is only selected by one student, based on the use of Scratch. Only one student integrated an educational gamification strategy through the creation of a game based on a “lucky wheel”.

Discussion

Games are considered among the tools to develop new skills for the 21st century. For the 21st century skills and competencies to be identified and enhanced within the present and future classrooms, the teachers are required to be trained to the pedagogical and efficient utilisation of a vast variety of strategies and techniques. With such tools in their belt, they have the capability to use the appropriate and most effective strategy each time, according to the learning targets and the context.

Based on the case study results, it appears that Serious Games (SG) could be considered to be more generic in their utilisation compared to the other strategies, tools and techniques. This can possibly because SG do not need additional training and programming skills as for example gamification and Scratch. SG foster and support active learning that enable the learner to have some control of the game activity and engage in interaction. For the teachers the active learning methodologies in SG encourage learning activities by building on engagement and challenges. Playing SG could develop a “gamer disposition” that could foster learners to thrive on change, discover new insight and learning how to overcome obstacles (Brown & Thomas, 2008). SG can expand the possibilities for reflectively exploring phenomena, testing hypotheses, constructing objects and aiming at providing students with challenges related to the main learning task (Kandroudi, Bratitsis & Lambropoulos, 2014). In conclusion, SG playing can be exploited for knowledge construction, and can facilitate, if not enhance, motivation as well so to promotes learning engagement.

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

DEFYING THE ODDS: TEACHER DEDICATION AND CUTTING EDGE TECHNOLOGIES TURN AROUND AN UNDERPRIVILEGED SCHOOL

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Introduction and Motivation

In Cyprus, public primary schools (state-run, free of charge) account for more than 92%[1] of total students. Elementary students are assigned to schools based on their home address. All schools are assumed to be equally good and the Ministry of Education absolutely refuses to publish any data that could be construed as documenting differences in public school quality. Gossip fills the vacuum of reliable information and in many cases, parents trick the system in order for their children to go or avoid going to a particular school. The Elementary School of Agios Spyridon in Strovolos (Lefkosia), Cyprus, has been (and to some degree still is) one of the schools avoided by affluent, educated or concerned (informed or misinformed) parents; they prefer to send their children to a nearby school, with a new building and an –unfounded-reputation of being a much higher quality school. Bothe schools suffer as a result: one from overcrowding, the other from lower educational and socioeconomic student background.

Internal school records (2013-2015), show 40% of Agios Spyridon student families are immigrants (one or both parents) from Eastern European or Asian countries. Almost half the families are single-parent, and over a third of students receive free lunch or/and their families are supported by state welfare services. The school has been avoided by parents and teachers alike for almost 20 years now. Low student moral has been cause and result of the school students' local reputation as 'not good, below average, with behavioural issues'. So about five years ago the teachers of this school were those who chose to "stay and fight" accepting the challenge to help the students rather than request transfer to a more 'fertile' environment. This attitude is not groundless sentimentality: According to OECD (2011), "disadvantaged students can and often do defy the odds against them when given the opportunity to do so. This includes offering these students equal opportunities to learn, and fostering their self-confidence and motivation so that they can exploit their potential".

The achievements

During the past three years, contrary to expectations, the Elementary School of Agios Spyridon has received more than 10 national and international awards; it performed the first 3D printing in any school in the country, created and hosted the first Computer Museum in

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[1] Official data from Cyprus Statistical Service for 2013/2014, www.cystat.gov.cy

Cyprus, and joined the European Week of Code as the only public school integrating coding in the curriculum and involving parents throughout the school year. This success and recognition is due to the efforts of pupils, parents, teachers and headmistress of the school; but attributing it just to persons will not help other underprivileged schools to make similar progress. In this paper we present some of the ways this has been achieved, including of course the use of ICT resources but definitely not being restricted to those.

Use of ICT

In 2009, the school had a computer lab with 14 Windows-based PCs and an interactive whiteboard. A mobile lab of 22 OLPC-XO laptops was assembled, thanks in part to donations from the Greek Open Source Community, as part of a worldwide pilot implementation. In order to do the best possible implementation of laptops within the school curriculum and to suit the needs of most teachers, we made sure that we met some criteria (Warschaeuer, 2010): Laptops were freely given to students to take home, especially when assignments called for them. Two classrooms (first and sixth grade) were equipped with interactive whiteboards and video projectors as a temporary 'loan'. A donation of older Apple Macs (based on the PowerPC architecture) helped equip the first grade with its own computer lab. Students and parents were informed that the school was the country's first with 3 computer labs, including a mobile one that could serve the entire school. A Moodle-based LMS, Mathisis.org, was used, so that students could work on online assignments: it is the oldest such system used in Cyprus, customised for use in primary education (Kofteros et al., 2008). The following three years saw an expansion of technology integration in every classroom, with interactive whiteboards in all classrooms, and an additional mobile lab consisting of 20 Android Tablets. Video conferencing became a normal procedure for students, actively collaborating and participating in activities with schools from Greece, Italy, Norway and South Carolina (USA). Students were also allowed to bring their own tablets to school in specified days, for use during the lesson in specific learning activities, also for their personal use during breaks, following strict rules for proper internet utilization. Agios Spyridon was the first primary school to implement a "Bring Your Own Device" initiative, while offering extra tablets or laptops to students without access to one. BYOD is gaining ground in education, since many students already own mobile devices with internet connectivity that can be used in the classroom, enabling teachers to maximize the potential of ICT with the minimum cost (Burns-Sardone, 2014).

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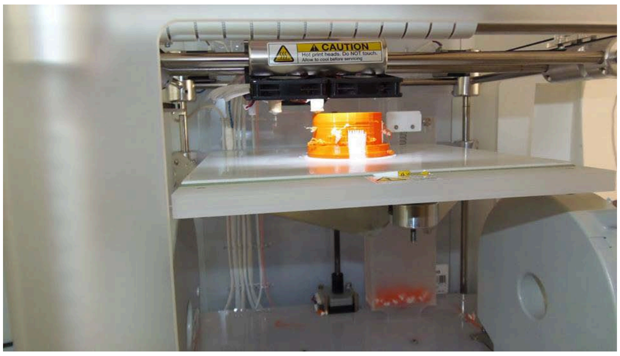

Figure 1. 3D printing @ school

Through Open Discovery Space and the "3D printing @ school" initiative, the school reached out to the local private sector and borrowed a 3D printer. Based on a scenario written by the teachers of Agios Spyridon and implemented across the curriculum with the collaboration of grades 3 to 6, students recreated the Neolithic settlement of Chirokitia (7000 B.C.) and created the first 3D printings for any school in the island. At the same time, students were receiving awards for their research on such topics as Violent Video Games, Violence in Cartoons, Use of Facebook by primary school students, and for the development of a solar-powered school bag that can charge their laptop (Research Promotion Foundation, "Technology & Innovation in Education" Competition). ICT was essential in all these initiatives, since students learned how to research various topics using the internet on the tools provided by the school. By early 2014, a ratio of 1 device per 2 students was established, an unheard-of ratio even in the rich and expensive private schools of the island. Students were becoming aware of all the infrastructure their school enjoyed that was unique for the entire country and that they –for the first time- were the privileged ones.

The use of ICT was not confined in how students used it for day to day tasks. Integration of video games and Augmented Reality was examined. Research has shown digital games to promote students' learning motivation (Chen & Hwang, 2014) and they have an impact on complex problem solving (Eseryel et al., 2014). Students were also requested to seek the past of computers, and a huge project was undertaken by fourth to sixth graders to create the first computer history museum in the country, located in a previously empty classroom and consisting of more than 100 items from the 1970s (Apple II), most of 1980s (Sinclair, Amstrad, Commodore, Atari) up to 1990s (NeXT, Apple, Sun, Silicon Graphics). An official ceremony by the Vice Mayor and representative of the Minister of Education was held at the school and covered by the media (CyBC). The museum is open for visits by schools and thus far we have had visitors from all over Cyprus, including a school from Greece (2nd Kalyvia Primary).

Computer Programming was considered to be essential and was integrated throughout the school year 2014-2015 in various subjects (Maths, Modern Greek, Design and Technology, Science) and for almost every grade. Programming has been a part of ICT in education for more than 30 years, with new programming environments such as Scratch which are based on the principles set by Papert with his original Logo (Papert, 1993). The school organized events

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during the European Week of Code (11-17 of October, 2014) and was the only primary school in Cyprus to participate for the entirety of its duration, including a whole-day set of activities on Sunday, October the 12th, with parental engagement. For the last day of the Week of Code, a 'codeathon' was organized, with the participation of 5 schools – Agios Spyridon, a visiting school (Agglisides Primary) and other 3 schools (Apostolos Loukas Primary, Kyperounta Primary, 2nd Kalyvia Primary) through video conferencing.

Figure 2. Our new versatile desks, chairs and classroom arrangement

Understanding that new technology requires new ways of working in the classroom, we completely redesigned the learning environment and created what we called 'Classroom 2.0'. According to Leiringer and Cardellino (2011), "the design of flexible and functional environments makes possible the adoption and adaptation of emerging changes in education and is a necessary precursor to educational transformation". We used specially designed desks with round edges and larger working areas, modularly shaped to combine into a circle or a wave (when placed sequentially but in opposite direction) for students to face each other. Chairs were replaced by rotating seats and wheels to allow easier placement in the class and the ability to turn and face whichever student or teacher wants to present information. Students have personal lockers, which is not common in Cypriot public schools. Students have access to tablets with their personal Google apps for education account, offering Single Sign-on to both their email, online apps (Word processor, Spreadsheet, Presentation) as well as access to Moodle (www.mathisis.org), Mahara (eportfolio) and BigBlueButton (video conferencing).

The Human Factor

It was common understanding among school teachers that Agios Spyridon students where characterized by low self-esteem, decreased intrinsic motivations and almost absent extrinsic motivations from their families. Lack of extrinsic motivations from families may lead to increased academic achievement (Katz et al., 2011). To a large degree, even teachers had low expectations on what students could achieve. At the end of the school year, when the school managed to attain the third place in the "Students in Research" competition, held by the Research Promotion Foundation (http://research.org), even the headmaster was surprised. Students self esteem started to improve once they were engaged in after-school activities that helped them differentiate themselves from other schools (such as participation in an online 'opera' with a school from Norway – WASO Project). Also, the fact that they had access to

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unique and cutting edge technology that no other school had, like laptops for every student or 3D printers, has made them see themselves as 'unique', 'special', 'one of a kind'.

Parents were, and at a large degree still are, absent from school activities, with low academic expectations from their children. However, they do recognise the change in how their children perceive the school, and the improvement in their (children) self-esteem, based on the opportunities for engagement in various competitions and activities. When parents are engaged in working with their children at home, an improvement in academic results can be achieved (Epstein et al., 2009). Ironically, most parents that show the most interest in working with the children are parents from Eastern European Countries instead of Cypriots. Even though most of these parents have not (yet) mastered the language, they are more eager to support their children and follow advice from school. We have been helping them through various seminars (Greek Language Lessons) and an online platform (www.dimotiko.info) with the tools to contact teachers regarding school progress. Through this platform we have delivered personalised instruction to students who were found to be at risk. According to Jewitt et al. (2011), such an approach allows students and parents to work with their own pace and in their own time, with significant learning results.

Teachers initially had low expectations from their students. We still believe that, even though progress has been made, a lot of students still have no intrinsic or extrinsic motivations for academic achievement. However, we have begun to understand that students, when given the right opportunities, even those we often regard as 'not caring', 'not capable of exceling in something' can surprise us in positive ways. In order to achieve this, all teachers worked hard as a team, for longer than expected hours, including weekends or public holidays. This dedication, along with the understanding that everyone was part of a time, helped push the school forward without any (serious) disagreements or problems. To quote John Wooden, a famous American Basketball coach, "the player who makes the team great is more valuable than a great player – losing yourself in the group for the good of the group, that's team work". By the end of 2014, every single teacher in the school was using the internet and interactive whiteboards extensively in their teaching, while half of them participated in ICT related competitions.

The headmistress of the school played a crucial role in helping change the school. Initially, the previous headmaster, who had done a great work at organizing the school and assembling a team of dedicated teachers, was very sceptical with low expectations on what (Agios Spyridon students) could achieve. When we first participated in the "Students in Research" competition, even the (then) headmaster of the school had low expectations on the results, emphasizing that "it will be a good experience, never mind the place we end up at". In the following three years, the next headmistress is very supportive and encouraging participation in various projects (such as ODS) and competitions. She was also allocating what available budget was available in purchasing ICT equipment and establishing a wireless network covering almost the entire school. She also supported initiatives such as the creation of the fist Computer History Museum, collaboration with other schools, participation in competitions,

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while at the same time dealing with all the necessary paperwork and doing away with any obstacles that might have slowed us down. All this, of course, based on the mutual trust that whatever teachers were doing was always for the benefit of the student and that teaching time was never 'lost' on extra curricular activities.

Figure 3. Computer History Museum

External Contributing Change Factors

A school, any school, is part of a larger ecosystem in which it resides and operates. As such, various institutions played a major role in the change that occurred in the specific school. The Ministry of Education, in collaboration with the Research Promotion Foundation (RPF), handling research funding, organize the annual 'Students in Research' competitions. This competition is considered to be one of the most demanding. Students must select an appropriate topic, write a research proposal, including research questions, make a literature review, select methodology and tools, gather data, write the final research paper and present it to a committee consisting of an academic, a member of the RPF and a member of the Ministry of Education. Very rarely, as it is extremely demanding and time consuming, schools participate more than twice in this competition. So far, Agios Spyridon is the only school in the country with five submissions, for four consecutive years, with an equal number of awards (Research Promotion Foundation, 2012-2015). With the new school year (2015-2016) we will have at least one new submission. Moreover, sixth grade students will have participated in the competition for three consecutive years, and they will be coaching the fifth-graders with their first participation. Sixth graders will have had more experience in writing a research proposal, conducting the research, writing and presenting the research paper than many university undergraduate students! The Ministry of Education, along with the Pedagogical Institute of Cyprus, organize an annual ICT competition in which teachers from any school can present innovative ways of integrating technology in their classroom. For the past 4 consecutive years we have presented Agios Spyridon work in this competition. For the past two years, more than half of the teachers are presenting their work in this competition –taking place during an all-day event- gaining more rewards than any other school. In fact, from the four final proposals during the 2014-2015 competition, three belonged to Agios Spyridon.

A major opportunity that allowed the school to promote its work throughout Europe was the participation in the Open Discovery Space project. The Open University of Cyprus suggested joining the project since the first stage of its implementation, and we continued through to the last stage, creating our online community and uploading content (more than 300 files,

ISBN 978-615-5511-06-6

including multimedia content, assessments, activities etc). The opportunities to join innovative projects such as 'Write a Science Opera', 'Akritan Music', '3D printing @ school' to mention a few, allowed us to push our boundaries beyond even our own expectations. Through these projects, the Greek National TV (ERT3) asked us for an interview on our collaboration with the Greek school in Gaydos, and the Athens daily 'Kathimerini' published an article on how our school collaborates over the internet with other schools from Greece in Science education. The collaboration in innovative projects, the coverage from the local and Greek media, as well as the promotion of our work with press releases sent to all partners through the ODS network, helped to seriously boost the morale of both teachers, students and parents, and establish among our school's ecosystem a feeling that our school really excels in anything we attempt to do.

Conclusions

The new school year (2015-2016) will find the school with a new headmaster, a person who specifically requested to transfer to our school since he is an ICT supporter and recognizes the significant work of our school in this particular area. However, in spite of the students' public accomplishments, the majority of parents are still immigrants. We do not view this as a failure –we have managed to make a dent to what was the original image of the school. The Ministry has recognized the potential of the school, and teachers who had never intended on coming to work to our school have begun requesting transfers. We have given our students unique and in some ways unparalleled opportunities, and their moral has been seriously boosted. Now, when asked about their school, they refer to it as the 'multiple award-winning primary school of Agios Spyridon'. We still need to convince parents, but this change will take time. We have even prove, with the technological infrastructure of the school, that even in times of economic disparity there are always opportunities for acquiring infrastructure at schools: donors exist and they are ready to give or lend in return for good will; open source software and older (used) equipment are quite all right for school needs; good, consistent and prompt use of available funding especially within a long-term plan, goes a long way towards meeting learning requirements

Note

Alexandros Kofteros is a teacher at the Agios Spyridon Elementary School, Strovolos, Cyprus and a Doctoral Student at the Open University. Thanasis Hadzilacos is a professor of Educational Technology at the Open University and the National Coordinator for ODS in Cyprus. The authors acknowledge and thank the other members of the Open University ODS team in Cyprus, Anna Mavroudi, Kyriakoula Georgiou and Maria Fraggaki and the teachers of the school, Theodora Zakou, Neofita Varnavides, Maria Vorka, Maria Theofanous, Soulla Pantela, Sofia Demetriou, Ioanna Kkalla and Soulla Pantela (headmaster).

ISBN 978-615-5511-06-6

Awards

Research Promotion Foundation Awards (http://research.org.cy):

> *"What videogames sixth graders play and what their parents know" (2011-2012), third place.*
>
> *"Are cartoons today more violent than the cartoons our parents watched? What sixth grade students and their parents think (2012-2013), first place.*
>
> *"Do parents know what fourth grade students do on Facebook? (2013-2014), second place.*
>
> *"Possible changes on how fifth grade students use Facebook, after the announcement of the results of the research conducted school year 2013-2014" (2014-2015), Honorary Mention.*
>
> *"Development of a school bag that solar-charges OLPC XO laptops", (2014-2015), second place*

Pedagogical Institute of Cyprus Awards (http://www.pi.ac.cy):

> *"3D printing @ school: 3D model of Chirokitia Neolithic settlement, a multi-disciplinary Approach". (2013-2014). Innovative Practice award, teacher: Stavri Vasileiou*
>
> *"Improving the motivation for reading books using technology: a collaborative online course with 4 schools". (2013-2014). Best practice award, teachers: Alexandros Kofteros & Neofita Varnavides*
>
> *"Week of code: integrating computer programming across the curriculum". (2014-2015). Best practice award, teachers: Alexandros Kofteros & Matina Marathefti.*
>
> *"Integrating students from remote schools to a city school for Science Education" (2014-2015). Teacher's Choice Award, teachers: Alexandros Kofteros, Stalo Solea, Agathi Tzouti.*

ISBN 978-615-5511-06-6

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

TECHNOLOGY TRACES ON CHILDREN HANDWRITING

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The Project

Handwriting in educational settings has seen changes in practice, culturally and at social level. In particular, the practice of handwriting is less necessary in daily life because it has been replaced by other means of communication for sending messages, making appointments, expressing feelings etc. To this should be added the effects of the reduction of the ability to coordinate perception and mobility which corresponds to the substitution of handwriting with the use of a keyboard.

Nulla dies sine linea project, coordinated by Benedetto Vertecchi and developed at LPS – Laboratory for Experimental Research – Università di Roma TRE, aims at verifying handwriting effects in the learning processes of a group of approximately 380 primary school children based in Rome and its district (grade III, IV and V). In four months, the teachers asked pupils on a daily basis to write a text of four lines in III grade, five lines in IV grade and six lines in the V grade. First results highlight mainly a strong support in the motivational dimension, which teachers note in everyday practice when they inform pupils about the title of the daily composition they have to write: pupils participate actively, enjoy it and are involved and eager to express themselves in writing.

The main hypotheses formulated are the following:

- that a correlation exists between the practice of handwriting and the quality of the text produced;
- that handwriting corresponds to a gratifying brain activity;
- that when the ability to handwrite grows, there is a corresponding diminution of the difficulties which are often interpreted as manifestations of a mental health disorder;
- that to the practice of handwriting corresponds an overall increase of literal skills.

The Context

The present contribution, analysing some of the texts produced by the children from grade III and V, participating in the project, is addressed to identify traces that an unsupervised use of technology, as it normally happens in contemporary primary school children lives, may leave on their writings.

The analysis is based on those compositions regarding their favourite pastime, taking into consideration it as the area where the use of technology is more likely to occur at this age.

Focusing on this area, moreover, allows reflection developments, starting from that "meaning construction" and "knowledge of reality" which Bruner (1991) considers as strongly contextualised and therefore linked to storytelling.

The idea is that of taking inspiration from children's compositions in order to observe, however at a pre-experimental level, which symbolic links can be identified between pastimes and technology, in the construction of reality carried out by children at this age.

The relation between digital tools and writing skills represent an issue, which affects different fields of analysis, from the educational to the neuroscientific one, without neglecting sociological implications which the deepening of the theme necessarily implies. Each of us, and the youth in particular, everyday, using their smartphones, tablets or computers, communicates more and more frequently through electronic text messages. This daily practice does not mean, unfortunately, a corresponding improvement in writing skills. On the contrary various international studies (Kirschner & Karpinski, 2010; Junco, 2011; Junco & Cotten, 2012; Cingle & Sundar, 2012; Wei et al. 2012) highlight a significant decrease in writing argumentation ability for those who practice an excessive use of such communication tools. Implications of such an intensive use, especially at school or pre-school age, can worsen the situation, as already identified by research on university students.

Maybe for the same reasons, most Silicon Valley's CEOs, apparently, send their children to schools like the Waldorf (Ritchel, 2011), where any technological device is banned. To tablets and whiteboards they prefer knitting and wood marquetry, which, according to the school leadership, support mathematical skills, problem solving and synthesis. Technology in this phase of education is seen as a source for distraction, which limits socialisation with peers and teachers. Students prefer handwriting at Waldorf, because they state they can realise their improvements, which is impossible using keyboards and automatic revision.

Handwriting is object of various neuroscientific studies. Different experts underlines pre-school and school differences in pupils' learning abilities where digital devices are employed to write, compared to those who handwrite their texts (Longcamp et al. 2008; 2011; Spitzer, 2013).

This activity has an impact on reading comprehension, because, it stimulates different areas in the brain and, in particular, those engaged in reading. Handwritten letter recognition ability is connected to the same muscular movements engaged in reading and this activates, at the same time, specific visual receptors linked to memorization abilities (Longcap et al., 2011). A specific study from China demonstrated that computer writing strongly limited primary school children reading abilities (Tan et al., 2013).

The quoted examples highlight the existing need to reflect on education as harmonic development of future generations, because tomorrow's adults could be citizens able to

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contribute in common welfare. Educational research has the fundamental function of addressing the most useful paths, to carry out the above objective, and projecting tools that could be fruitful in the long run.

Preliminary lexicometric analyses

The purpose of the research project *Nulla dies sine linea* was to identify some trends in handwriting practice of primary school students over a period of about four months. Preliminary lexicometric and descriptive analyses were carried out on the set of texts collected, that formed a corpus of approximately 1,807,836 characters, corresponding to 393,696 words.

It was required to the scholars to write 4, 5 or 6 rows of text depending on what class they belong. In Italy, children enter in primary school at age of 6 years old. Primary school lasts 5 years, and children are grouped into different classes based on their age.

In order to compare text written by children of the same age and school level, we chose to consider three different *sub-corpora*, considering pupils' grade. Nevertheless, it is possible to consider all the text as a whole corpus in order to increase its size and to obtain more reliable measures (about 380 pupils).

Into this preliminary analysis we took into consideration also background data other than grade: sex, age and school. We also asked if the student was an immigrant in Italy for more than a year, if he or she had a specific learning disability or disorder.

Methodology, Analyses and Findings

The research group engaged in the project analysed compositions realised by pupils from three classes in grade III and 4 classes in grade V, involved in the research and based at the *Tor de' Schiavi* and *Mar dei Caraibi* schools based in Rome, on January 16th 2014, when children had to write an essay on the topic "My favourite pastime".

91 texts (4 lines in grade III e 6 lines in grade V) were collected in grade III and 126 in grade V. As the graphics below show, from a first reading of children' productions, preference on electronic or non electronic pastime can be identified.

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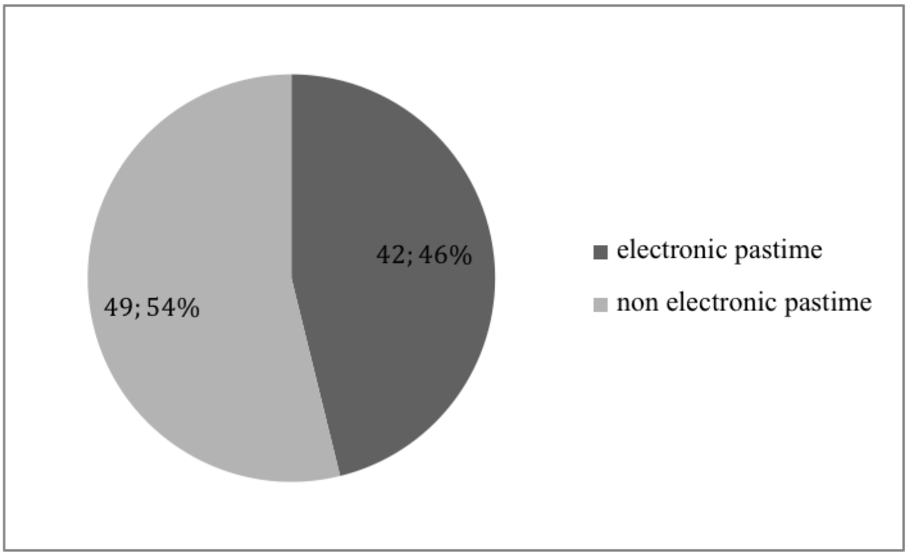

Figure 1. Pastime preference – grade III

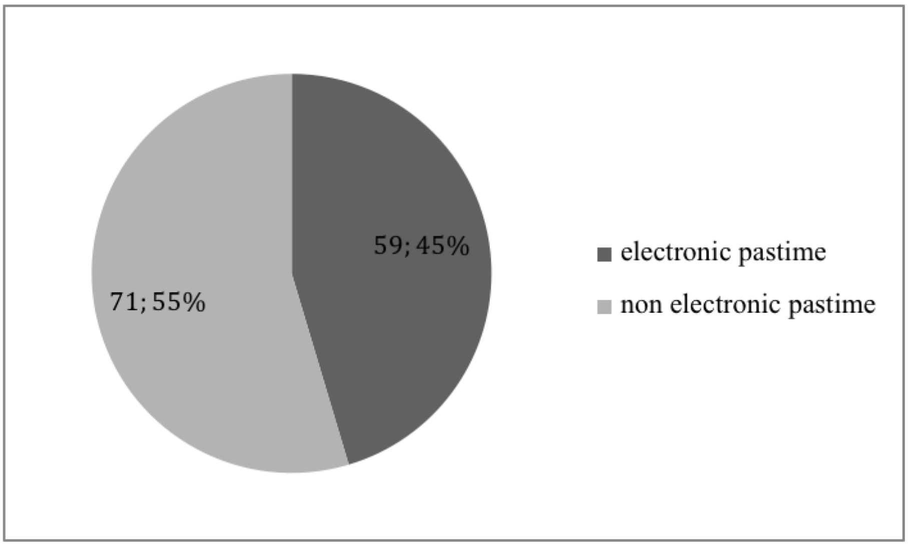

Figure 2. Pastime preference – grade V

Taking into consideration that non technological pastime (e.g. soccer, war simulation, cards) is integrated in consolidated habits of every child from any time and represents, from a "structural" point of view, a sort of model, which proved to be stable and constructive in the long run, it is impressive to note from the data collected that 42 children out of 91, in grade III, and 59 children out of 121, in grade V, tell of being passionately involved in technological pastimes. As it can be noted the this aspect is more evident in grade III compared to grade V and this means either that the phenomenon is more integrated in everyday life so that it is not worth mentioning anymore or technological pastimes are simply more transient than the more traditional ones.

If we analyse word frequencies in children's texts we see that this aspect is confirmed.

The word "videogame", for instance, appears just once, like "console". The word "computer" occurs just 4 times, "tablet" just 5 times. "Cellular" and "Smart" does not occur, but

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"telephone" twice (meant as cellular phone). From a semantic point of view it is as if "telephone" could include "cellular" or "smart".

As far as all the other cases are concerned the exact tools name are mentioned: Nintendo, WII, Playstation, PSP or directly the name of the game of interest (Just dance, GTA 5, FIFA etc.).

It can be concluded that there is a more intensive use of hyponyms compared to hyperonyms. Hierarchical organisation in hyperonyms and hyponymes allows a schematisation of the language and therefore of experience and meaning development, because the hyponyme name (e.g. GTA 5) inherits all the characteristics of the higher level hyperonyme one (electronic game) with some additional element linked to its specificity. Technological terms used, being hyponyms, intrinsically acquire higher level semantic characteristics.

Tag Cloud images below show the density of frequencies and allow visualising above mentioned concepts.

Figure 3. Tag Cloud – My favourite pastime – Grade V

Figure 4. Tag Cloud – My favourite pastime – Grade III

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Though limited, the analysis carried out with primary school children texts reveals a significant assimilation of technological elements in 8-10 years old children's lives. What Eco (1979), from a semantic linguistic point of view, in accordance with Bruner's idea, calls real reference world and mentions as cultural construct (p.131) shows itself as characterised by habits, knowledge and contexts, strictly linked to the presence of technological devices.

Final remarks

Data collected suggest supporting research projects aiming at identifying the level of impact, if any, that such contexts, as the technological one, have on pupils learning abilities in a developmental phase.

We cannot stop technological progress and the availability of technological device which improve our welfare, but as contemporary educators, we need to reflect, deepen and propose models for an aware and constructive use of available technology, so that they can be truly helpful for pupils' growth and development.

If as Vertecchi (2014), reminds us, quoting Quintilian, the best teacher is the one who willingly replies to pupils' questions, we should not isolate them behind a screen but we should help their socialisation and interaction abilities with peers and teachers to let them grow authentically, humanly and critically.

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This paper has been written and edited by Antonella Poce, a part from the section "The Project" by Benedetto Vertecchi and the section "Preliminary lexicometric analyses" by Francesco Agrusti.

ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

'GETTING TO KNOW YOURSELF AND THE OTHERS': USING LMS FOR A COLLABORATIVE ICT & LITERATURE PROJECT

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Introduction

This paper consists of a collaborative ICT and Literature project using the Blended Learning methodology (Bong & Graham, 2006). A total of 80 students from four (4) elementary schools participated in this project (Greece: 3, Cyprus: 1) taking advantage of the Open Discovery Space European Program initiative for authoring and applying pioneering educational scenarios.

The current educational scenario is compatible with the Greek National Curriculum by means of integrating Literature in school life and preoccupying creatively with literary texts, taking at the same time advantage of the capabilities ICT offers. It is also compatible with the New Greek National Curriculum by means of setting the aims and the governing principles of education (Berk & Winsler, 1995; Schaffer, 1996), focusing on students feeling free to act on their own (Bruner, 1960; Gardner, 1991) and co–authoring the educational material with their teacher (Bruner, 1982), leading to enriching the educational praxis with activities introducing research work and procedures (Smagorinsky, 1996; Lloyd, 2012).

Main Aim

The main aim of the project was to offer the opportunity to all the participant students to communicate with each other by many different means, synchronous and asynchronous, setting the studying of a book (Brenifier, 2010) as the reference point. Through the 'Mathisis' (www.mathisis.org) LMS platform (Moodle) all the participants were able to share and discuss the work of each other, collaborate and interact through the designed applications.

Secondary Aims

Introducing and understanding

1. Students are introduced to the basic characteristics of the characters described in the source book, analysing at least one such characteristic.
2. Students are able to come to an understanding of how people react in different ways to various incidents and situations, depending on the psychological type they belong to,

and justify through commonly accepted paradigms (Jung & Baynes, 1921; Vygotsky, 1978).

3. Students are introduced to working through peer network learning environments (Slavin, 1995), participating in at least three (3) applications.
4. Students are able to apply and compose data segments of the reference body of text to digital productions, uploading and displaying their work on the specially designed web space.

Researching and spotting

1. Students are able to spot the differences amongst two contradictory characters, after studying each and every pair of characters in the book, justifying their opinion critically in a commonly accepted manner.

Communicating (and collaborating with others)

1. Students collaborate with the rest of the participants and communicate with each other using the specially designed workspaces in a commonly accepted manner.
2. Students are able to organise, plan and share their work with the rest of the participants on the specially designed web space making use of the applied tools.

Connecting (with life)

1. Students are able to realise that every single behaviour and effort to solve a problem is closely related to one’s character and way of seeing things.
2. Students are able to spot, distinguish everyday behaviours and relate them to the corresponding psychological types they have studied in the book.

Project description

The current project consists of two (2) phases.

Phase I (2013 – 2014)

The educational scenario had been set up before the beginning of the school year. The minimum skills required by all students were decided then: use of web browser (Chrome, Firefox etc.), use of e-portfolio (‘Mahara’ – https://mahara.org) and use of LMS skills.

Activity 1: “Let’s get to know each other”

A tele-conference between the four schools took place at the beginning of the school year using ‘BigBlueButton’ (http://bigbluebutton.org) and Moodle, aiming at:

- Motivating the students to fully engage in the collaborative lessons following
- Making the students practice their verbal and communication skills
- Making the students develop web 2.0 tools skills for writing texts
- Being able to use the basic tools of the LMS

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Figure 1. Tele-conference using the BigBlueButton

Activity 2: "Le livre des grandes contraires psychologiques"

The book chosen for the collaborative activities presents ten (10) pairs of contradictory human characters (i.e. 'Introvert' / 'Extrovert'). An avatar was also selected to guide the students through their study on the characters. All content and activities were created and published on the LMS and most of the work was finished at school, aiming at:

- Introducing the students to the book and the methodology upon which they were supposed to work
- Making the students able to focus on and analyze the characteristics (pros / cons) of every character in the book
- Giving the students the opportunity to express and assert their opinion verbally

Activity 3: "Make a painting of the two characters"

All students had had the opportunity to make a sketch or painting of the way they perceived the characteristics of the 'Simple' and 'Analytic' pair of characters or write a small text, which they uploaded on the e-portfolio, aiming at:

- Letting the students express freely their creativity in art
- Making the students able to share and comment on the whole of the works published online
- Giving the students the opportunity to improve their own work with ideas quarried from the works of others

Activity 4: "Idealist and Realist"

All students initially studied the pair of characters and pointed out the pros and cons through teamwork. Then, they used the 'Word Magnets' tool (https://www.tripticoplus.com) to present their work on the interactive board, aiming at:

- Making the students able to utilize web tools to record their views and conclusions
- Giving the students the opportunity to express and assert their opinion verbally

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- Introducing the students to important Aesop's Myths and making them able to express verbally the moral of every story
- Making the students able to argue in order to support their opinion

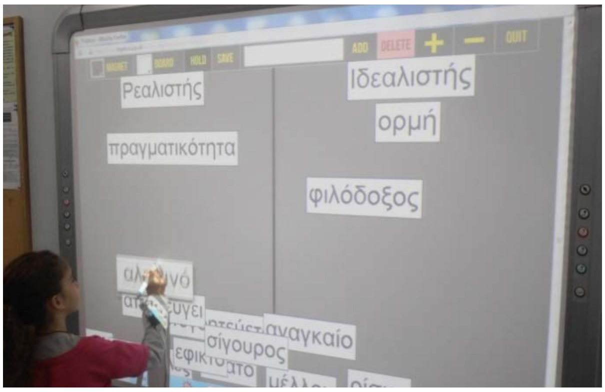

Figure 3. Using Word Magnets in Class

Activity 5: "Individualist and Sociable"

All students initially studied the pair of characters and pointed out the pros and cons through teamwork. Then, they studied the types of constitution (democracy, monarchy etc.) and tried to sort out the characteristics of each one. Finally, they used the 'Linoit' (http://en.linoit.com) tool to present their work on the internet by means of virtual stick-it notes, aiming at:

- Making the students able to collaborate with students from other classes or schools on a common project
- Giving the students the opportunity to utilize the output of peer activities in order to support their opinion in written form
- Introducing the students to constitution types and match every type of character with the corresponding type of constitution according to their characteristics

Activity 6: "Introvert and Extrovert"

All students initially studied the pair of characters and pointed out the pros and cons through teamwork. Then, each student had to answer in written form how each character would act in a party she's invited, aiming at:

- Making the students able to point out a character's pros and cons through team work
- Making the students able to reconsider their initial ideas or views through class debate
- Making the students able to take a character's place by means of a web activity

Activity 7: Collaborative Activity with all of the participants

All participants participated in the closing tele-conference using 'Google Hangouts' (https://plus.google.com/hangouts) and the 'Symphonical' (https://www.symphonical.com) add-in. Using Symphonical, each class from the four different schools posted their views on the pros and cons of all the character types they had studied so far.

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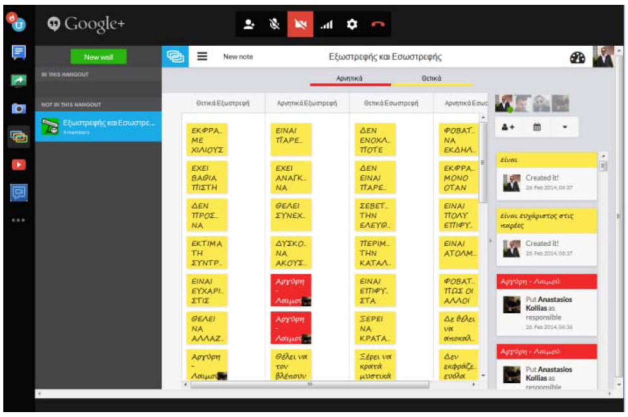

Figure 5. Google Hangouts & Symphonical: real time peer collaboration

Evaluation Activity

Although all the participants had been evaluated through certain tasks in every activity, they were also given a final evaluation test consisting of a sum of 80 multiple choice questions. Every student had to answer only 20 randomly selected by the system questions. Once he had completed the test, the system showed the overall score along with the correct and incorrect answers.

Phase I Evaluation

During the application of the project, all the participants (educators and students) had the opportunity to enjoy the tools and the capabilities ICT have to offer, to brace one's skills or develop new ones. Students were motivated by the use of a very popular means of communication, as the internet is, while they were given the opportunity to ponder on issues of proper use of such tools and technologies.

At the same time, all participants got to know better their selves and the others in terms of realising various aspects of their characters and behaviour. All this helped improve the overall class and school community climate.

Minor setbacks arouse from students that was difficult to conclude their work on the web at home, although there was the alternative of printed out activity forms for those who did not have internet access at home. Even students with internet access had to deal with technical issues, but they were dealt by providing more time to conclude every activity.

Team work and peer collaboration activities had a highly positive impact on all the students, leading to developing their communication and collaboration skills. Minor problems concerning team synthesis were dealt by rearranging the teams or reassigning tasks to the team members.

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Phase II (2014 – 2015)

Phase I consisting of communicating and collaborating using the tools of the LMS online platform. Phase II consisted of working together in person, applying at the same time all the things we experienced and learned during phase I. Two visits were eventually planned and carried out.

One day visit to 2nd Kalyvia Elementary School

The visit took place in March 2014. The students of Argyri Laimou Private School spent one day with their friends at the 2nd Kalyvia Elementary School. Both the teachers had prepared a rich visiting schedule which included activities in class based on phase I of the project and using tools like 'Tagxedo' (http://www.tagxedo.com), drama and improvisation activities based on the book character types carried out by mixed teams (from students of both schools), art activities (creation of original paintings), environmental activities (planting a small olive tree) and sport activities.

Figure 6. Activities in class by mixed teams from students of both schools (Kalyvia, Gerakas)

Trip to Cyprus

The trip was made last April (2015) during the Orthodox Easter Holidays. The students the 2nd Kalyvia Elementary School, accompanied by their parents and teacher and the teacher from Argyri-Laimou Private Elementary School visited Cyprus for 3 days.

Figure 7. Visiting the history of computers museum (Agios Spyridonas Elementary School, Nicossia)

The teachers and students of Agios Spyridonas Elementary School welcomed us at their school, where we all had the chance to meet with the people we were talking and working together for a whole year and a half through the LMS. The teachers form Cyprus had prepared

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a rich 3-day visiting schedule including visiting the history of computers museum they have created inside their school, visiting the fully equipped classroom (class 2.0) with interactive board, tele-conference equipment and tablets, and of course our common visit at the ancient cite of Choirokitia, the Neolithic settlement dating back to the 6th millennium BC.

Figure 8. At the ancient cite of Choirokitia Neolithic Settlement (Larnaca)

Conclusion / Discussion

Using synchronous (video conferencing, chat) and asynchronous (forum, email) means of communication, students had the opportunity to meet other students, even from schools in another country, and improve their writing and talking skills through their collaboration. This collaboration motivated them to work more closely with the activities organized by their teachers, and it became evident when students were eager to work on the material provided, both when technology was involved (activities on Moodle) and with pen and paper activities. In total, 80 students were engaged with the study of the source book and the activities created based on it, with the students working even after school hours, on their own, using such tools as the Chat room (Moodle) to communicate and chat with other students, not necessarily for activity-related discussions, but on a more informal basis. Following the rules we had set (no 'greeklish', no impolite discussions), students were motivated and actively engaged in practicing their writing skills –and even their typing skills- on an almost daily basis. The use of games such as the 'game module' (Moodle) with its crosswords and simple hangman activities, helped students better understand their vocabulary. Overall, students showed an increase interest in the lessons, they were actively engaged in all the activities, and they were very happy to collaborate with other three schools even beyond school hours.

The project was submitted and presented to the annual ICT competition of the Pedagogical Institute of Cyprus (May 2014) and received the "Best Practice" Award, further proof of the success of the scenario and its implementation.

ISBN 978-615-5511-06-6

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

STUDYING THE FLIPPED CLASSROOM MODEL IN PRIMARY SCHOOL HISTORY TEACHING

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Introduction

Social studies school teaching is challenged by both the use of technology and the adoption of inquiry-based teaching strategies in Science, Technology, Engineering and Math (STEM) courses. Typically, in traditional history/social studies school curricula, emphasis is given in memorizing large amount of historical content namely, (names, dates and facts), making these courses less attractive to students [1]. Furthermore, still, many history/social studies school teachers in traditional settings use most of their teaching time for lecturing and assessing students' ability to memorize content. As a result, typically in these settings, students' active engagement in historical critical thinking learning and assessment activities is limited [2]. Research studies also report that students have common misconceptions about historical knowledge, primary sources, human motivation and historical change which are not overcome easily with traditional teaching strategies [3]. As a result, there are systematic efforts to enhance teaching, learning and assessment of history and social studies school courses, by exploiting innovative pedagogical design supported by technology [4].

At the same time, the "flipped classroom" has gained prominence worldwide, as a technology-supported pedagogical innovation which uses classroom time for students to actively engage in interactive learning activities including feedback and scaffolding, while traditional teachers' lecturing is delivered out of formal class time with asynchronous video lectures [5]. Yet, there are limited efforts in studying the application of the "flipped classroom" model in primary school and, in particular, in history / social studies courses.

In this paper, we argue that adopting the "flipped classroom" model in a primary school history / social studies course has the potential to use classroom time in a more efficient way than traditional lecturing, overcoming the well known problems mentioned above, leading to improvements in students' enhanced learning outcomes.

Based on this hypothesis, we present an action research conducted to study the following research questions:

- RQ1. Can the implementation of the flipped classroom model in a primary school history course lead to better students' learning outcomes?

- RQ2. Can the implementation of the flipped classroom model in a primary school history course contribute to a more creative use of teaching time?

The rest of the paper is structured as follows: Section "Background" presents a short literature review of the flipped classroom model and its implementation in teaching history / social studies school courses. Section "Study Methodology" describes the methodology of the conducted action research and section "Results" presents the results obtained in relation to the two research questions. Finally, Section "Discussion and Future Work" refers to the benefits and possible challenges of the flipped classroom model.

Background

The flipped classroom model is an emerging blended learning model widely used both in school and university formal educational settings. The "flipped classroom" has gained prominence worldwide, as a technology-supported pedagogical innovation which uses classroom time for students to actively engage in interactive learning activities including feedback and scaffolding, while traditional teachers' lecturing is delivered out of formal class time with asynchronous video lectures. Based on sound pedagogical theoretical principles, "flipped classroom" targets to exploiting classroom time and space for appropriately designed interactive learning activities, differentiated according to individual and group students needs. These studies report that the flipped classroom model increases student – teacher and student – student interaction as well as improves parent – teacher relationships [6].

The flipped classroom model has been implemented in history and social studies middle and/or high school courses. Typically, in such implementations, the classroom-based face-to-face time is used by teachers for discussions on the video lectures previously watched, for primary and secondary sources analysis, for debating, writing and peer reviewing [7]. Studies report an increase in student's learning outcomes in historical content memorization as well as in the cultivation of historical critical thinking skills ([1] and [2]).

Study Methodology

Study Context and Participants

Our study was conducted in a two-terms-long (twenty four weeks) history course at primary school. More specifically, the "Roman and Byzantine History" course in 5th Grade of the Greek primary school curriculum was the context of this study. The participants of the study were the 26 students of the experimental group and the 23 students of the control group who attended this course at a private primary school in Greece during 2014–2015. These two groups were selected because i) all students had access to a computer and an internet connection and ii) they demonstrated similar learning achievements in the history courses that they had attended during the previous two school years.

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Procedure

The design of the course was based on the application of the flipped classroom model for the experimental group and a traditional lecture-based teaching model for the control group. The learning goals were formed after studying international standards for teaching history[1].These learning goals were common for both study groups and they were grouped into categories and subcategories:

- **Category A: Historical content memorization**, namely, to remember and recall names, dates and facts from the long-term memory.
- **Category B: Historical Thinking skills cultivation**:
  - **Understanding the concept of time**, namely, to distinguish between past, present and future time, to identify and use the temporal structure in a historical narrative, to measure and calculate calendar time, to interpret data presented in time lines and create time lines.
  - **Understanding historical sources**, namely, to identify the author of the historical document, to identify the historical facts of the source, to differentiate between historical facts and historical interpretations, to draw upon data in historical maps, visual, literary and musical sources.
  - **Historical analysis and interpretation,** namely, to analyze cause-and-effect relationships, to argue using historical evidence, to hypothesize on how different historical actions could have let to different results, to formulate historical questions, to evaluate the actions and decisions of historical persons based on their results.

The students of the experimental group prior to attending classroom activities studied the video lectures in their online digital classroom that was implemented using the Moodle course management system. They interacted at the forum by publishing questions, comments or answering to their classmates' questions. They also took quizzes that consisted of closed ended questions based on what they had previously studied. For those who had the time and interest, extra material was provided, relevant to the video lectures. During the face-to-face classroom sessions, first, the students were involved in Q&A activities with the teacher in order to solve any questions that remained unsolved. The teacher then assessed their historical content memorization by verbally asking questions. The assessment was followed by the teacher's feedback on students' answers. The remaining teaching time was spent in engaging with historical thinking skills (HTS) cultivation activities. Students collaborated in order to complete the activities, debated and in general were actively engaged. The teacher observed the whole process and gave directions and feedback. At the end of each unit the assessments of the two main categories of learning goals took place. Students completed standardized tests with open and closed ended questions referring to historical content memorization and HTS

[1] i) National Council for the Social Studies –National Standards for Social Studies Teachers, http://downloads.ncss.org/NCSSTeacherStandardsVol1-rev2004.pdf ii) Common Core State Standards - History/Social Studies - Grade 6-8, http://www.corestandards.org/ELA-Literacy/RH/6-8/ iii) UCLA National Center for History in Schools-Historical Thinking Standards, http://www.nchs.ucla.edu/history-standards/historical-thinking-standards/overview

ISBN 978-615-5511-06-6

cultivation. The assessments were followed by the teacher's feedback on students' learning outcomes. The students were rewarded with digital badges.

The students of the control group during the face-to-face classroom sessions were exposed to traditional lectures on the new historical content. After the lectures, Q&A sessions with the teacher followed in order to solve questions that were created during the delivery of the new content. The remaining teaching time was spent in engaging with HTS cultivation activities. Most of the times though, the remaining teaching time were not sufficient enough. When the students of the control group returned home, they had to study and practice using their textbook, the historical content that was delivered to them. They could also use digital resources (articles, images, presentations) that were published in their digital classroom (the control group had the same access to resources as the experimental group except for the video lectures). If they had any questions they could publish them in the forum. Following their home-based individual study, they attended classroom-based follow-up sessions which started with Q&A activities and then the teacher assessed their historical content memorization and HTS cultivation (same as in the experimental group). The assessment was followed by the teacher's feedback on students' answers and the delivery of the new historical content. At the end of each unit the assessments of the two main categories of learning goals took place. Students completed standardized tests which were common to the experimental group.

Instruments

In order to collect data concerning the use of teaching time, teacher logs were created that documented in every teaching hour the flow of learning activities and the teaching time spent in each activity. The memorization of the historical content was assessed with standardized tests. In order to assess HTS cultivation, assessments were created by the teacher that included open and closed ended questions on primary and secondary sources. For the evaluation of the students' answers the "Assessing Historical Thinking and Understanding (ARCH): Historical Thinking Skills Rubric" of the University of Maryland, Baltimore County (UMBC) Center for History Education was used[2]. Each assessment question was linked to one learning goal and was evaluated by the rubric's criteria. The tests were common for the two groups and included the same open and closed ended questions as well as the same grading scale (from 0 to 10).

Data Collection and Analysis

At the end of the first term the teacher logs that recorded the flow of educational activities were collected and all assessment grades were gathered. The first research results were analysed based on those data. After reflecting on the first term's results, the primal instructional design was revised and the second action cycle commenced. At the end of the second cycle the second term's data were gathered and the data collection process was completed.

Following data collection, the data analysis was divided into the following tasks: i) analyze the distribution of teaching time in learning activities for the experimental and the control group

[2] http://www.umbc.edu/che/arch/rubric.php

in the first and second term; ii) analyze the students' learning outcomes in the historical content memorization assessments for the experimental and the control group in the first and second term; iii) calculate the effect size in order to statistically examine the significance of differences in student historical content memorization achievement scores between the experimental and the control group; iv) analyze the student's learning outcomes in the HTS cultivation assessments for the experimental and the control group in the first and second term; v) calculate the effect size in order to statistically examine the significance of differences in student HTS cultivation achievement scores between the experimental and the control group; vi) an overall evaluation to identify the benefits and possible challenges of the flipped classroom model. The calculation of the effect size was based on the standardized mean difference and evaluated based on Cohen's interpretation [8].

Results

The purpose of the study was to examine the benefits of the flipped classroom model relating to the use of teaching time and the students' learning outcomes. This section summarizes the results that corresponded with the two research questions as mentioned in Section 1. Table 1 presents the distribution of teaching time in learning activities for the experimental and the control group in the first and second term.

Table 1: Distribution of teaching time in learning activities

	Lecture	Assessment of historical content memorization (verbal)	Q & A session/ Feedback	HTS cultivation activities	Standardized tests
1st term					
Exp. group	0 min.	95 min.	100 min.	440 min.	90 min.
Control group	220 min.	130 min.	145 min.	115 min.	90 min.
2nd term					
Exp. group	0 min.	150 min.	120 min.	195 min.	75 min.
Control group	210 min.	110 min.	110 min.	115 min.	75 min.

As Table 1 depicts, lecture was the main activity that the control group spent most teaching time in, whereas the experimental group spent no time in this activity. This is due to the implementation of the flipped classroom model in the experimental group that transferred lectures entirely to the individual learning space. The control group also spent more time in (verbal) assessment of historical content memorization than the experimental group. The increase of teaching time spent by the experimental group in (verbal) assessment of historical content memorization in the second term is due to the revision of instructional design, as a result of teacher's reflection to first term teaching and learning analysis. It was observed that the students of the experimental group who were less often verbally assessed on historical content memorization were not as well prepared as the students of the control group that were more often verbally assessed on historical content memorization. For that reason, in the

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second action research cycle, the teacher spent more time assessing that learning goal in the experimental group.

Moreover, in the first term, the control group spent more teaching time in Q&A sessions and feedback than the experimental group. This is due to the fact that the experimental group students participated more actively in the Moodle forum, asking most of their questions before coming to class. The students of the control group preferred to ask questions and, hence, received feedback at the time when the new content was delivered to them, during classroom sessions. In the second term though, the teaching time spent in Q&A sessions and feedback by the experimental group was increased, because the time spent in assessment of historical content memorization had also increased. Therefore new questions came up especially from students that came poorly prepared to the class.

A significant difference of teaching time spent by the experimental group in HTS cultivation activities is observed in the first term. This is due to the implementation of the flipped classroom model that released teaching time and allowed students to engage in HTS cultivation activities. The decrease in teaching time spent by the experimental group in HTS cultivation activities in the second term is due to i) the revision of instructional design as described above and ii) the fact that teaching hours became fewer in the experimental group compared to the first term because of school schedule (field trips etc.). Finally, the two study groups spent equal teaching time in standardized tests, which were common for both groups.

Table 2: Assessment of historical content memorization (study groups' achievement score means in standardized tests)

	Diagnostic Assessment	1st Formative Assessment	2nd Formative Assessment	3rd Formative Assessment	4rth Formative Assessment	Summative Assessment
	1st term			2nd term		
Exp. group	8.45	8.82	8.97	9.15	8.38	8.63
Control group	8.54	8.80	8.67	9.01	8.67	8.63

Table 3: Assessment of historical content memorization – Effect size calculation

	Diagnostic Assessment	1st Formative Assessment	2nd Formative Assessment	3rd Formative Assessment	4rth Formative Assessment	Summative Assessment
	1st term			2nd term		
Effect size	0.06	0.02	0.25	0.15	0.21	0.003

As Table 2 depicts, the experimental group had in general the same or higher achievement scores in historical content memorization than the control group. There is only one different observation, the fourth formative assessment, which is considered an isolated event. The calculation of the effect size in Table 3 indicates however, that there is a low statistical

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significance of differences in student historical content memorization achievement scores between the experimental and the control group.

Table 4: Assessment of the HTS cultivation (study groups' achievement score means in standardized tests)

	Diagnostic Assessment	1st Formative Assessment	2nd Formative Assessment	Summative Assessment
	1st term		2nd term	
	Understanding the concept of time			
Exp. group	5.58	7.02	6.92	7.12
Control group	5.33	5.87	5.98	6.20
	Understanding historical sources			
Exp. group	5.58	6.73	6.54	6.83
Control group	5.22	5.54	5.65	5.76
	Historical analysis and interpretation			
Exp. group	5.38	6.92	7.02	7.12
Control group	5.00	5.98	6.09	6.30

Table 5: Assessment of the HTS cultivation – Effect size calculation

	Diagnostic Assessment	1st Formative Assessment	2nd Formative Assessment	Summative Assessment
	1st term		2nd term	
	Understanding the concept of time			
Effect size	0.13	0.60	0.53	0.45
	Understanding historical sources			
Effect size	0.19	0.70	0.60	0.65
	Historical analysis and interpretation			
Effect size	0.22	0.55	0.55	0.43

As Table 4 depicts, the experimental group had in general higher achievement scores in HTS cultivation than the control group. This is observed in all three learning goals' subcategories. The calculation of the effect size in Table 5 indicates that there is a high statistical significance of differences in student HTS cultivation achievement scores between the experimental and the control group.

Discussion and Future Work

Benefits of the Flipped Classroom Model

From the results of the study presented we can conclude that the flipped classroom model contributed to a better and more creative use of teaching time since it released teaching time from lecturing to other interactive activities. Consequently, in the experimental group, more teaching time was available for the students to actively engage with learning activities that promote cognitive learning goals of the higher levels of Bloom's revised taxonomy (Analyse, Evaluate and Create) [9].

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The calculation of the effect size showed that there was a low statistical significance of differences in student historical content memorization achievement scores between the experimental and the control group. This means that both study groups had similar learning outcomes in historical content memorization although the students of the control group spent significantly more teaching time with teacher's lectures compared with the students of the experimental group who spent no time for live lectures during classroom-based face-to-face sessions. This observation can lead to interesting hypotheses for future investigations:

- The teacher's lectures in the control group may not have been *engaging* enough in order to increase students' learning outcomes in historical content memorization.
- The video lectures made for the experimental group may have been as engaging as needed in order to promote learning outcomes in historical content memorization similar as teacher's live lectures.

The calculation of the effect size also showed that there was a high statistical significance of differences in student HTS cultivation achievement scores between the experimental and the control group. This means that the students of the experimental group who spent significantly more classroom time in engaging with learning activities that cultivate their historical thinking skills had better learning outcomes than the students of the control group. If we take under consideration that the HTS cultivation is a process that takes place mainly inside the classroom, it is reasonable to assume that there is a cause and effect relationship between the classroom time spent on HTS cultivation and the learning outcomes of HTS cultivation. In other words, the reason that the students of the experimental group had better learning outcomes than the students of the control group, may strongly be the fact that they spent more classroom time on HTS cultivation activities.

Challenges of the Flipped Classroom Model

Aside from the benefits of the flipped classroom model that are described above, there are certain challenges in its use that need to be taken into consideration. First of all the process of creating a course based on the flipped classroom model requires significant time invested on behalf of the teacher in order to develop learning activities and resources for the classroom. In addition, it was observed that some students of the experimental group were not enough self motivated and they did not thoroughly prepared themselves through watching and interacting with the video lectures nor did they study the material in general. The result was that they came to class unprepared. This led to less participation and engagement from those students who consequently fell behind. Therefore, it is important that the teacher is empowered with tools that facilitate him in monitoring individual students' home-based preparation activities and collect data that can help him re-design activities based on differentiated instruction principles. Overall, if the flipped classroom model is to be widely adopted, tools for learning and teaching analytics are required to support teachers as reflective practitioners.

ISBN 978-615-5511-06-6

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Acknowledgement

The work presented in this paper was conducted as part of the first author's MSc Diploma Thesis at the MSc Programme "Digital Systems and Services (Track on e-Learning)" of the Department of Digital Systems, University of Piraeus, Greece and it has been partly supported by the State Scholarship Foundation (IKY) under the grant No 30275/2013B (IKY Fellowships of excellence for postgraduate studies in Greece – Siemens Programme).

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

EDUCATIONAL INNOVATIONS IN THE BULGARIAN SCHOOL AND THE ROLE OF LIBRARIES IN THEIR IMPLEMENTATION

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Introduction

The educational system in Bulgaria includes four degrees of education: primary, pre-secondary, secondary and higher. With a few modifications since 1891, according to the Constitution of the Republic of Bulgaria, the National Education Act and the ratified international documents, amongst which the Convention on Children's Rights, access to educational services has been provided to all adolescents free of charge (for the state educational institutions) and obligatory until the age of 16.

It is interesting to discover that in the past, and even now, the Statistics Department with the Ministry of Justice (nowadays the National Statistical Institute) has gathered information as to how literate the population is (reading and writing skills). There is no information about some years since "in the late 1940s and early 1950s there was a directive to eliminate illiteracy and in the late 1950s it was assumed that in Bulgaria there were no illiterate people" (България 20 век, 1999), and yet the available information confirms the thesis that facilitating the access to education, the percentage of basically illiterate members of society declines, as well. 2011 was the year when the 17th counting of the population took place. The question "Are you literate?" was present in the count board (Национален статистически институт, 2011).

And if in the past it was considered that to be literate being able to read and write was enough, today the meaning of this word surpasses the original in many ways. All international organizations are united in their opinion that the main capital of countries is the potential of their citizens. This potential is associated with their education and their participation in the process of lifelong learning and "allows everyone to live a healthy, responsible, successful and independent life" (Министерство на образованието и науката, 2014). As defined by UNESCO "literacy is an ongoing and continuous process of training and/or learning that enables people to achieve their goals, to develop their knowledge and potential and to participate fully in the community and in the society to which they belong" (UNESCO, 2004).

Adoption of Strategic Documents

The main conclusion that can be formulated on the basis of international studies conducted since 2000 is that the quality of educational services in Bulgaria does not meet the modern requirements of the labour market and therefore many of the students completing their studies are not really competitive to their peers from other EU countries and the world. PISA and PIRLS have both proved that the traditional Bulgarian educational model where the teacher provides information and the student should remember it and then reproduce it is extremely inefficient. This is one of the reasons why parents and teachers do not see the connection between the subjects taught at school, the related to them qualitative build-up of knowledge and their application in practice and in real life.

New challenges for education were placed with the adopted in 1999 Strategy for Information Society Development in Bulgaria, according to which "all citizens must be ensured equal access to modern, efficient and quality telecommunication and information services, and equal opportunities for learning how to use them" (Стратегия за развитие на информационното общество в Република България, 1999). In this sense, another document was ratified – a National Strategy for Implementing ICT in the Bulgarian Schools (2005-2007)", whose main purpose was to computerize the system of primary and secondary education, to provide access to the Internet and the opportunity to apply ICT in the process of learning and last but not least, to raise teachers' qualification. (Министерство на транспорта, информационните технологии и съобщенията, 2005). Some national programs were implemented "Information and Communication Technologies at School (2008-2015)", the latter being granted 7,500,000 BGN, and among the basic indicators for its implementation is the "implementation of different ICT innovations (smart classrooms, video learning, etc.)" (Министерство на образованието и науката, 2015).

Potential of the Serious Games

So, after the renovation of the existing material and technical base through the realization of the above mentioned documents, what is the application of ICT in the learning process in the primary, lower-secondary and secondary education? Over the last decade Bulgarian teachers have reviewed the classical forms of training of students and have focused on new ways of working to make students active participants in the educational process. Traditional lessons in the classroom where the teacher is the central figure and the students are passive, has been replaced with learning activities in which students play a central role. Active learning is an effective strategy for training not only in a traditional classroom, but also online. The interactive method means "interacting in a mode of discourse and dialogue with someone. Unlike active methods, the interactive ones are oriented to wider communication of the students not only with the teacher but also with each other to dominate the activity in the learning process. The teacher does not provide ready knowledge and encourages students to search for themselves; they are full participants in the process of perception, their experience is a major source of educational knowledge. Sometimes active and interactive methods are equated, but there are differences between them. Interactive methods can be regarded as the most advanced form of active methods" (Чантов & Славова, 2012). Learning activities can be diverse – group work, role plays, case studies, simulations, seminars, problem solving, task-based, etc. It is noteworthy that special attention is paid to the implementation of the so-called serious educational games in learning – one of the fastest growing areas in the field of modern educational technologies widely used. Educators in Bulgaria share the observations of experts

ISBN 978-615-5511-06-6

that “students are very active on social networking sites, they excel at multi-tasking, they prefer visual information over text and are oriented toward a combination of media in education" (Knol & de Vries, 2010). Therefore, educators seek not to underestimate these facts but take advantage of new competences of young people and their alternative viewpoint.

Educational games are computer simulations allowing students to practice various interactive tasks. They offer a model of the real world and focus on situations of everyday life. Serious games are designed for a wide range of platforms – PCs, game consoles and mobile phones. The game begins with instructions for its purpose and ground rules to which the learner must adhere. Then “a participant in the game is placed in a particular situation and to achieve academic purpose, he or she must respond to the situation many times” (Енчева, 2011). Thus the student positively affects the outcome. The aim of the game can be determined both by the designer or the teacher and the student. Children’s experimentation, manifestation of imagination and role-play constitute the basic aspects of the educational dimension of these games (Meyer & Sorensen, 2009).

One of the main problems in education is the difficulty for participants to remain motivated enough. Educational games, offering challenges and fun can boost motivation for training and curb this problem. Due to their fascinating nature that engages participants for a long period of time in a relaxing environment, these games also contribute to overcoming the barrier in the relationship between teachers and students. Studies show that in comparison with the classical model of education, learning based on games is far more preferable, interesting, stimulating and providing challenges for the participants. It contains within itself the potential to provide in a simple way of learning new information and allows students to learn with confidence and store the acquired knowledge in their minds for longer.

It was found that educational online games are more effective than independent educational applications and foster collaboration through training. Collaboration in training stimulates students and makes the learning process more thorough. Adding newsgroups, use of chat and conferencing in the web-based course motivate learners to participate frequently in various joint activities and improve the quality of the discussions. Virtual teams can be just as effective as those operating in traditional training. Moreover, collaboration mechanisms, integrated in platforms for e-learning, contribute to the implementation of comprehensive and spontaneous communication between and among students and between students and their teacher. Members of the group receive objective attitude on the part of the instructor, and he or she in turn can monitor the performance and behaviour of students. Aided by the communication mechanisms in interactive web-based training, students increase their self-esteem – they are free and ready to oppose in relation to the ideas and opinions expressed in the course of the joint training activities. (Енчева, 2014). The gaming approach is suitable for use in training that reflects the ideals and principles of constructivism. According to this theory training is organized around student learning and is an active process of constructing knowledge (Kim, 2005). Teaching is not just providing information to students but support to the constructive handling of the facts on the part of the student.

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Educational Innovations in the Bulgarian School (2011-2014)

A comprehensive study on the educational innovations in the Bulgarian school in the last few years does not exist. Since it is not possible to cover in full all initiatives in Bulgaria related to the implementation of innovative learning approaches in schools **we will review the materials from the scientific-practical forum “Innovations in Teaching and Cognitive Development”** held for the first time in 2010. For this purpose, **innovations implemented in the period 2011-2014 are classified according to their areas of application**, again without claiming to be completely exhaustive. Let’s not ignore the application of innovative pedagogical methods of learning applied and/or developed to respond to the current situation and requirements of children in kindergartens. **It is mainly focused on the activity of the children in their play, work with tablets and interactive boards** (Образование и технологии, 2014). A good example is the educational program “Information Technologies in the Kindergarten” developed to integrate the modern information technologies in the educational and upbringing process, which includes educational games, multimedia situations and interactive board situations” (Образование и технологии, 2013, p.51) as well as “integrating interactive toys” [“Fun Bees” (BeeBot),”My Voice”, “Camera in Hand”] in cognitive process in kindergarten, designed to form spatial concepts, logical thinking, to develop communicative speech and creative skills in children” (Образование и технологии, 2014, p.76). According to the results of developers' experimental work, toys can be used “in the beginning to update the knowledge, to motivate and learn new material, and in the end – to summarize the knowledge and create an emotional atmosphere” (Образование и технологии, 2013, p.54).

Of great significance for the successful realization in social life are the acquired language competencies. Bulgarian schools curriculum includes the obligatory studying of Bulgarian language, as well as foreign ones. According to Yordanka Nikolova “ICT that play a significant role in the educational process for the formation of language competence are: presentations, using Mouse Mischief; e-diaries; portfolio; e-library; e-mail; training devices for perfecting the reading techniques, writing skills, spelling and speaking rules; computer-based games; e-materials” (Образование и технологии, 2011, p.142). As for the feedback from applying the Microsoft tool Mouse Mischief in reading and assessment of Bulgarian Language and Literature, it guarantees the teacher the conduct of real formative assessment because the parameters for further help in the course of training are given, which is necessary to each and every student” (Образование и технологии, 2014, p.122), and “the emotional atmosphere and game elements make studying more interesting” (Образование и технологии, 2011, p.139). The software for classroom management NetSupportSchool can also be applied to Native language studies, which allows teachers to train, observe and interact with every student, with different groups or with the whole class” (Образование и технологии, 2013, p.77). Internet-based programs (e.g. Voki for Education and Wikispace) also have a place in “foreign language studying which requires social interaction between the teacher and the students, as well as among students themselves” (Образование и технологии, 2011, p.221).

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The students' creativity in education is stimulated by the platform ZooBurst which is a "digital tool for storytelling, allowing for the creation of own 3D pop-up books, and a powerful tool for classroom management" (Образование и технологии, 2013, p.130). Specialized software educational solutions can be applied when studying arts, and especially in the music classes. An experiment has been conducted in Primary School "Stefan Karadja" in Dobrich and the results show that "studying has become more entertaining, interesting and involving to students" (Образование и технологии, 2014, p.157).

A serious issue in the last few years has been the reluctance of young people to read. One innovative solution has been found in the educational portal eTwinning, which offers the integration of different tools in the learning process, as well as the opportunity for students to communicate with students from other European countries (Образование и технологии, 2014). For the project "We travel with Hans Cristian Andersen, the Mystery, Magic Land of Fairy Tales" in 2013 Stela Nikolova from Primary School St. Kliment Ohridski in Pleven was awarded the European Label for Quality (Основно училище "Св. Климент Охридски", 2015).

Information on the approbation of the Microsoft tool Mouse Mischief in the subject "The Environment" which aims at "forming initial concepts and notions of the natural environment" we can find in the paper by Anichka Petrova and Rositsa Georgieva, according to whom "computer and information technologies are not just one modern educational element. They complement, diversify, modernize and motivate the lesson without displacing the traditional methods and approaches" (Образование и технологии, 2014, p.171).

Information on the application of the educational software HP Classroom Manager in the field of natural sciences (Physics and Astronomy) can be found in Nedyalka Trayanova's publications, according to whom "seminar lessons with modern methods of data management, gathering and processing in real time allows students to come as close as possible to scientific experimenting" (Образование и технологии, 2013, p.99). Besides, a change has been observed in the "motivation to study and students' involvement in class, improvement of students' intellectual skills and an increase in tolerance" (Образование и технологии, 2013, p.103).

For the realization of human dreams and ideas, and the achievement of personal and professional prosperity knowledge is necessary for the application of what Aristotle defined as "the science of quantities" – mathematics by which today we understand that body of knowledge relative to quantitative relations, types of space and spatial structures and the performing of calculations (Александрова, 1989). The training on this subject in schools meets the application of various forms to reinforce the already acquired knowledge and skills as well as the formation of new ones. The multimedia presentations "avoid the uniform repetition, an opportunity is given to solve more practical tasks, the chances of self-initiation and creative participation are increased". (Образование и технологии, 2013, p.94). Another tool for diversification of traditional lessons, which allows the active involvement of students, is the dynamic geometry software GeoGebra, which "positively influences the cognitive

ISBN 978-615-5511-06-6

activity of students by developing and automating their skills" (Образование и технологии, 2013, p.193). The educational games are represented in this area too through the development of own software (Образование и технологии, 2014).

Attempts are observed to create and implement own products in the process of learning in subjects like "Informatics" and "Information Technologies", among which Captire Script, a "software application for working with code-cards, an environment for creating fragments of computer programs or complete programs in all programming languages" (Образование и технологии, 2013, p.185). Among the tools used is Microsoft KODU – a visual programming language with which children and students can create their own games (Образование и технологии, 2013). A serious interest in the last decade and probably in the next, there has been in the field of IT. So it is no surprise that among developed and proposed innovations are playing cards "Professions with computers" that "are only a provocation to systematic empowerment of students, parents and teachers to career development" (Образование и технологии, 2013, p.126).

When "people play, it is much easier to determine what their aims, aspirations, desires, strategies and policies are" (Гетова, 2014). **It can be concluded** that when designed effectively, serious educational game engages the emotions and minds of trainees in a consistent experience that enriches them with new ideas, concepts and skills. It is important here that the mistakes made by the participants are transformed into educational components. Game-based learning helps for the development of important competencies such as analytical and spatial skills, strategic and systematic thinking, psychomotor skills, visual selective attention, planning and problem solving, etc. Educational games contribute to the application of problem-based and situated learning. In this context, the modern school should seriously consider ways of integrating certain serious games into the existing curriculum or accepting them as an effective additional tool for learning.

A conclusion can be formulated from the presented review that the interactive forms and their application in the educational process not only have their own, albeit modest place in the training of young people and students in Bulgaria, but they are "factors for creatively oriented interaction for education from an early age" (Образование и технологии, 2012, p.40). The investment in education and technology and "the synergy between all stakeholders should lead to successful implementation of the education policy, acquisition of new skills and new knowledge, creating sustainable growth and quality of life" (Образование и технологии, 2014, pp.45-46).

Participation of the Libraries

Major stakeholders in our opinion are the school and the public libraries. In order the school library to be useful to modern generation of students and the school community as a whole, of crucial importance are the qualifications of library and information professionals, condition and composition of the library and how it meets the current information needs of the entire school community. According to the IFLA/UNESCO School Libraries Manifesto (1999), they

ISBN 978-615-5511-06-6

should provide students and school community with access to information resources of any kind (paper and electronic), by which to stimulate the development of critical thinking skills and efficient information usage skills, regardless of the type of information. The resources of the library have as their primary goal to complement the training material and to support students in their learning. The library as an institution should promote cooperation between teachers and librarians, with the result that adolescents develop their literacy, develop reading habits and their memory, acquire skills in information and communication technologies. Through their work they contribute to the development of literacy, the acquisition of IT skills, the creation of habits for continuous self-education, and involve children to the world culture (School Libraries and Resource Centers Section, 1999).

In accordance with these requirements and demanding tasks set for achievement by school libraries, it is necessary to ensure appropriate conditions and resources for their development so that they become "the heart of the education system", places that combine in themselves both the traditions of printed literature and new trends in information science. They should be part of the innovative processes and changes occurring in the Bulgarian educational system.

But what is the attitude of the direct users of library services? A comprehensive study on the state of libraries in our country does not exist. In recent years, we have conducted some surveys, but they are far from exhaustive. For example, in a survey conducted in the period 2010-2011 in the city of Sofia, it was found that the predominant motive for using the services of the school library by students is love for reading books (33%), 21.4% are attracted by the opportunity to learn more about specific topics of interest to them; 20.3% associate it with preparation for school and the least percentage of students (13%) visit it for recreation and solace. More than two thirds (65.2%) of respondents librarians cited as a factor for the outflow of readers the growth of the computer generation, the attractiveness of the Internet and the lack of appropriate conditions and technical resources to work with new technologies, i.e. they "accuse" technology instead of using it actively in the process of library and information services and supporting the uptake of educational content (Златкова, 2011).

Ginka Kalamova's study (2014, p. 43) makes it clear that according to 72% (of 22) from the respondents believe that the library stock of school libraries in Karlovo (2 in the settlement), is unable to fully satisfy the information needs of the school community, and among the priority issues are "procurement of new and modern information sources, providing the necessary (computer and audiovisual) equipment and Internet, provision of appropriate interior environment" (Каламова, 2014, p.67). As for perceptions of the school library of the future, according to 16 of the teachers, it is "virtual (electronic), provided with the latest technology, will have each published book, there will be room for multimedia shows, including cinema, it will be more spacious and will offer more services" (Каламова, 2014, p.70).

In the research of the PhD candidate Marchela Borisova more than 400 respondents (children educators, teachers, students, librarians and parents) have shared views on the role of public libraries in the maturation process of children and students. According to her, considering the

ISBN 978-615-5511-06-6

many global initiatives for early childhood development through active participation and cooperation with public libraries, "disturbs the position expressed by the children's teachers about the age when children first have to learn about and visit the library – more than half (57.7%) believe that the library should be part of children's lives once they start school, and according to 34.6% in the range of 2-5 years" (Борисова, 2015).

She argues that "the primary key form of partnership between the school and public libraries is to conduct classes in the institution, i.e. outside the formal educational space. It is highly impressive the appreciation of teachers who qualify this initiative as "very good", they respond with a great desire to express more fully their views on the implementation of this idea – 61.0%. According to Borisova, the high rate reflects the firm conviction of the respondents that the public library and school bear great responsibility for improving literacy which is important for the reading and information culture of students, a task with a national character" (Борисова, 2015). Confirmation is also found in the answer to the question "Do you think that partnership is crucial to improving literacy and the reading and information culture of the students?", which is a summary of the views of respondents about the benefits of the partnership as the share of those showing satisfaction is very high – 87.8% (Борисова, 2015).

Conclusion

Transformations in the perceptions of library space in recent years give rise to claims that libraries have already gone beyond the traditional book and, though still not very confident, digital reading and use of educational software are making their way. The survey results by Borisova show that if "the public library offers computers with different educational programs, 87.9% of the children responded that they would gladly prepare lessons and homework there and that would be an incentive for regular use of its resources. Thus in place the interconnection and interaction of traditional and electronic media is accomplished. The high proportion of children who wish to participate in this new form of learning taking place outside the school is an expression of their confidence and their willingness to change the educational process as a whole" (Борисова, 2015).

The quoted data gives us enough reason to believe that the application of innovative approaches in the learning process of Bulgarian students not only has a beneficial effect on the educational process, but also finds its place in libraries (school and public). The expansion of educational innovation plays a crucial role in breaking the still dominant traditional image of the library as an institution. As part of the organizational structure of the Bulgarian school and in line with the mission of public libraries in the country, they have responsible tasks – to provide conditions for the development of intellectual potential in accordance with educational requirements and to encourage the creative talents of children and students.

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Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

TEACHING AND ASSESSMENT METHODS IN THE FIELD OF MATHEMATICS, SCIENCE AND TECHNOLOGY

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Abstract

Education systems in Europe have not been able to address successfully the low achievement in the fields of Mathematics, Science and Technology. This failure increases social inequalities and reduces the number of students who select a career in Mathematics, Science and Technology disciplines as well as it increases the student drop-out rate in the Mathematics, Science and Technology disciplines, which constitutes an essential factor for sustainable, socially just, and inclusive growth. This paper aims to investigate teaching and learning assessment methods, teaching strategies and best practices, in order to support the development of a sustainable strategy for low-achieving students in Mathematics, Science, and Technology. The main thrust of this research is to explore the application of "threshold concepts" in different learning situations where learners are engaged in key learning processes of Mathematics, Science and Technology.

Key words: teaching methods, assessment methods, MST education, threshold concept

Introduction

"As a society, we rely increasingly on a good education in Math, Science, and Technology (MST) to help us understand all of these issues and to manage the rapid rate of technological change which we see around us". According to well-established body of research, it is suggested that a solution to tackle this problem is to involve and engage students in teaching and assessment methods and practices so to trigger their interest and motivation for the Mathematics, Science and Technology (MST) subjects (Glynn & Koballa, 2006; Glynn et al., 2009; Ericsson, 2006; Rocard et al. 2007).

In social cognitive theory, students' learning is viewed as most effective when it is self-regulated, something that occurs when students understand, monitor, and control their motivation and behaviour, and leads to desirable learning outcomes. In this theory, motivation is defined as an internal state that arouses, directs, and sustains goal-oriented behaviour (Glynn et al., 2011; CAST, 2014).

To increase students' interest and motivation, we need to take into account educational and cognitive psychology (e.g. Bandura, 2006; Pajares & Schunk, 2001) and how these are related to students achievement as well as diversity issues related to different classes of low achievers, as they are classified by Sany (2006), as: i) lagging students, ii) slow learners, iii) low/moderate achievers and propose targeted activities, in alignment with the above mentioned classes, in order to adapt the activities to learners' cognitive and affective level. The strategy to tackle these is to engage students in inquiry and problem/project-based activities that include the threshold concepts and students will have the task to be involved in explorative and/or expressive models. Furthermore, augmenting physical environments by digital environments and resources will support learning actively and creatively. Teachers can enhance the experience of students through opportunities for formative feedback, networking and engagement (e.g. Virtual Learning Environments (Fragkaki, 2015)

Threshold Concepts

Threshold concepts (TC), represent a gateway to learning and understanding through which candidates have to pass but where they may encounter real difficulties of learning and understanding.

Some researchers argue that TC concept is in itself a threshold concept; as such it is only to be expected that some people will find it hard to grasp, both because of its transformative implications but also because of its intellectual difficulty and superficial resemblance to other common-sensual sets of concepts in the notoriously fuzzily-defined lexicon of education. Entwistle (2000) comments; "Initial discussions with staff suggested that it was quite difficult for them to grasp the essential transformative property of threshold concepts, with the term often being confused with the more commonly used idea of key concepts".

Examples of threshold concepts in MST

A threshold concept is thus seen as something distinct within what university teachers would typically describe as 'core concepts'. A core concept is a conceptual 'building block' that progresses understanding of the subject; it has to be understood, but it does not necessarily lead to a qualitatively different view of subject matter. So, for example, the concept of gravity – the idea that any two bodies attract one another with a force that is proportional to the product of their masses and inversely proportional to the distance between them – represents a threshold concept, whereas the concept of a centre of gravity does not, although the latter is a core concept in many of the applied sciences.

In mathematics the concept of a limit is a threshold concept; it is the gateway to mathematical analysis and constitutes a fundamental basis for understanding some of the foundations and application of other branches of mathematics such as differential and integral calculus. Another example is the concept of complex numbers, which is the gateway to understand and work on branches like waves and fluid mechanics. Mathematicians themselves are aware of issues that surround threshold concepts as it is evident from the work of Artigue (2001) who refers to ‘a theory of epistemological obstacles’ and, by way of summary, gives as a first example of such obstacles:

> *“…the everyday meaning of the word ‘limit’, which induces resistant conceptions of the limit as a barrier or as the last term of a process, or tends to restrict convergence to monotonic convergence…”.*

Motivation and interest of students for MST disciplines

Social cognitive theory, developed by Bandura (2006) and extended by others (e.g., Pajares & Schunk, 2001) construes human functioning as a series of reciprocal interactions among personal characteristics, environmental contexts, and behaviours. In social cognitive theory, students’ learning is viewed as most effective when it is self-regulated, something that occurs when students understand, monitor, and control their motivation and behaviour, and leads to desirable learning outcomes. In this theory, motivation is defined as an internal state that arouses, directs, and sustains goal-oriented behaviour (Glynn et al., 2011).

The study of motivation by science education researchers attempts to explain why students strive for particular goals when learning science, how intensively they strive, how long they strive, and what feelings and emotions characterize them in the process (Glynn & Koballa, 2006; Glynn et al., 2009). The role of motivation in influencing expertise is expected to be critical in any domain. Students who are highly motivated engage in behaviours and practices that lead to more expert knowledge and skills and, ultimately, to high performance (Ericsson, 2006).

Research indicates that some important features that should be taken into account when examining students’ motivation to learn science are intrinsic motivation, extrinsic motivation, task relevancy, self-determination, self-efficacy, and assessment anxiety (Glynn & Koballa, 2006). Motivation to perform a task for its own sake is intrinsic, whereas motivation to perform a task as a means to an end is extrinsic (Ryan & Deci, 2000). Students who are intrinsically motivated work on a task because they find it interesting; students who are extrinsically motivated work on a task to attain a desirable outcome such as a good grade, but both types of motivation are important in contributing to students’ success in their courses (Ryan & Deci, 2000). According to Pintrich and Schunk (1995), motivation is the process whereby goal-directed activity is instigated and sustained. This definition is made up of the following variables typically used as operational indices in motivation research: i) Task choice (i.e. selection of a task under free choice conditions), ii) Effort (i.e. high effort, particularly on difficult material), iii) Persistence (i.e. working for a longer time, particularly when one encounters obstacles), and iv) Achievement (i.e. increasing the above elements is expected to raise task achievement). Moreover, enhancing students’ employability through Science Technology Engineering & Mathematics (STEM) subjects will motivate students for contributing to the society and economy (Fragkaki, 2015).

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Inquiry Based Science and Mathematics Education (IBSE) and problem/project based learning

The field of science and mathematics education research is concerned with the development of high-level skills like concept construction, modelling, problem-solving, cognitive-metacognitive skills and scientific/conceptual processes. Science education is also concerned with helping students to develop knowledge about physical realities that is in line with the scientific knowledge.

Inquiry based learning has been officially promoted as a pedagogy for improving science learning in many countries (Bybee et al., 2008). Inquiry can be defined as "the intentional process of diagnosing problems, critiquing experiments, distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments" in alignment with the research in science education (Lederman et al., 2002; Lederman, 2007) and is often considered as a way to implement the science education research methodology in schools (Levy et al., 2010).

Inquiry is also a pedagogical method or teaching strategy, adopted by science teachers when they design learning activities that allow students to observe experiments and review what is known in light of evidence (Minner et al., 2010). Teaching science by inquiry requires communicating not only scientific information but also the abilities to do inquiry and, more deeply, an understanding of what scientific inquiry is about while it has to be considered as a set of instructional strategies aiming at developing high-level cognitive abilities (Psycharis et al., 2013).

Developing inquiry-based learning environments using computational science methods and tools seems to be an essential research issue in science and mathematics education. Bell et al. (2010), identified nine main science inquiry processes supported by different computer environments that could be used in inquiry-based science-mathematics education (IBSE), namely: orienting and asking questions; generating hypotheses; planning; investigating; analysing and interpreting; exploring and creating models; evaluating and concluding; communicating; predicting. The nine inquiry tools of Bell et al. (2010) are closely related to the essential features of Inquiry (Assay & Orgill, 2010), namely: Question (Learner engages in scientifically oriented questions), Evidence (Learner gives priority to evidence), Analysis (Learner analyses evidence), Explain (Learner formulates explanations from evidence), Connect (Learner connects explanations to scientific knowledge) and Communicate (Learner communicates and justifies explanations). There is a close relation between the essential features of Inquiry and the nine tools proposed by (Bell et al., 2010).

As an example of practicing this approach we can see an "Open Discovery Space" (ODS) resource, where students are faced with the realistic issue of personal and social decision-making when planning for hurricane strikes, which includes classification, tracking and monitoring hurricanes, as well as planning for evacuations. The inquiry-based approach involves a WebQuest in which the students will assume the role of emerging management

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team member who creates a preparation plan for the community (Coastal Weather issues: planning for a hurricane (Greene, 2015)).

How to measure and define low achievement

Below follows a list of five methods that could be used for measuring and defining low achievement:

1. One concrete methodology (Entwistle, 2000), is to initially identify the concepts students have through interviews/ with students and focused on what students believe learning to involve and how they go about everyday academic tasks, such as reading academic articles or writing essays (at the Tertiary Education) or how they are involved in Problem Based Learning (PBL) or Inquiry Based Learning (IBL) tasks in Secondary and tertiary level. The interviews generally encourage students not just to report their ways of tackling their tasks, but also to reflect on their approaches in considerable depth. Analysis of the interviews follows a rigorous procedure to establish categories and the relationship between those categories, a technique which contributes to a research approach described as phenomenography.
2. The second line of development is to design inventories which measure understating of these concepts and so allow relationships to be established in larger representative groups. The inventories usually produce sub-scales which cover the categories found from the interviews, with the definition of the categories being refined through factor analysis of the sub-scales. According to Entwistle (2000), these complementary strategies not only can establish relationships between inventory sub-scales, they also indicate how teaching and assessment, and other aspects of the teaching-learning environment, influence students' ways of studying and the levels of understanding reached. In this framework, we are going to identify low achievement as low measurement epistemic beliefs, low scientific reasoning, and low approach to learning.
3. Threshold concepts have the power to transform students' understanding (Scheja & Patterson, 2010). They can be thought of as 'the troublesome knowledge', 'conceptual gateways' or 'portals' that students must understand or traverse in order to become subject specialists (Meyer & Land, 2003). They are counter-intuitive and conceptually challenging and consequently many students often find them difficult to acquire (Meyer & Land, 2003), yet when a student does acquire a threshold concept, the ideas and procedures of a subject that previously seemed alien to them begin to make sense (Davies, 2006).
4. Engaging with Threshold Concepts can be thought of as transformative (occasioning a significant shift in the perception of a subject), irreversible (unlikely to be forgotten, or unlearned only through considerable effort), and integrative (exposing the previously hidden interrelatedness of something). In addition, they may also be troublesome and/or they may lead to troublesome knowledge for a variety of reasons (Meyer & Land, 2003). In an extension to their earlier work, Meyer and Land (2006a) expand the notion of threshold concepts to include student identity. Once they understand

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threshold concepts, students feel empowered by their new skills, understanding, and new command of language and associate this process with the feeling of 'becoming' a subject specialist. It is possible then, that understanding a set of threshold concepts contained within MST curricula will facilitate students to 'become' Mathematicians, Scientists, and Technologists. Students who are in the process of engaging with threshold concepts are known to struggle, encounter 'epistemological obstacles' (Meyer & Land, 2003), or become 'stuck' in their pursuit of new knowledge (McCartney et al, 2007). Perkins (1999), describes this process as troublesome; a state where students are actively struggling with new concepts and ultimately in a form of distress. Students that remain in this liminal phase, will often result in mimicry (Ellsworth, 1997), replicating information without understanding. Entwistle (1998), describes this approach to learning as 'Surface Learning'. Those who surface learn fail to engage with higher cognitive domains and levels of understanding, struggling to synthesise new concepts and failing to abstract these concepts into new applications. Ward and Meyer (2010), successfully attributed this 'rote learning' approach to 'problematic' low achieving students in their study of students' meta-learning capacity when engaging with threshold concepts. Attempts have been made to encourage 'Deep Learning' at the level of curriculum design (English et al., 2004). However, Bigg's (2003) advises through his SOLO taxonomy, that this process be scaffold and that intended learning outcomes (ILO's) are designed so that the appropriate level of understanding is expected of a student at the appropriate time in their study.

5. Triangulation - Mixed methods data capture. Learning experience. Since we are making the argument that the experience of engaging with threshold concepts can be universal, we should capture the experiences of the students as they engage with them. The experience of before and after experiencing threshold concepts will be very powerful information. An investigation of the use of blogs, student diaries or audio reporting systems, in tandem with the other data capture strategies will form a rich and valuable data set. This data set can be used to discover emerging qualitative indicators that suggest the presence of threshold concepts. It will also have the dual purpose of engaging the students with metacognitive thought processes and also for use in seeding constructivist learning scenarios. For example, students who have access to a database of the learning experience, will be able to experience a particular phase of learning with other students remotely, actively comparing their experience with that of others. The impact of this can be captured empirically.

Systemic Factors that contribute to reducing the number of Low Achieving Students (LAS)

A conducive school atmosphere and effective teaching are very important variables. Teacher's effectiveness could be developed through focused policy actions aiming at teachers' training. In traditional classroom settings, it may be practically impossible for a teacher to give individual help or attention to students with Low Achievement. Through involvement in computational thinking processes, it would be possible to develop a critical mass expert

ISBN 978-615-5511-06-6

teachers/tutors to provide higher cognitive level learning experiences on an individual basis. Expert tutors are known to improve student thinking and problem-solving skills to the level of the experts modelled by the tutor (Woodward & Brown, 2006).

Advantages of expert tutors for students with LA include the ability of expert tutors to present instruction in small sequential steps for problem solving, to provide variable levels of difficulty and review of concepts, and to allow students to work independently. Critical to the success of expert tutors used by students with LA is the analysis of student performance and use of effective instruction (Bos & Vaughn, 2002).

Furthermore, in order to create an effective learning environment for low achievers, attention should be given not only to the teachers training but also to the initiatives such as Open Discovery Space project through policy making (Open Discovery Space, 2015). This raises the questions about whether teachers are 'right' in believing that policy constraints simply get in the way of effective learning by i.e. limiting their autonomy, or whether they see any educational value in instrumental policy designed to protect and enhance the service in which they work (James & Pedder, 2006). Based on the Oxford Brook's Principles for the Strategy of Enhancing the Students Experience (SESE), educators need to inspire students and foster their intellectual development and well -being; encourage them to learn in ways that make a creative contribution to their personal growth and to the society; students being able to use technology to shape their learning environment and interaction. In this way, students will have the opportunity to exercise habits of learning through STEM that will be useful in their lives (Fragkaki, 2015).

The family and the school are considered to be also very important social-systemic factors contributing to academic achievement. It is often observed that in spite of having a range of similar intellectual levels, there are differences in academic achievement, among students coming from different families. Among the various related factors, the influence of the family in a child's learning is one of the most significant factors (Sany, 2006). The quality of the family interaction pattern is responsible for motivation (Marchant, Paulson & Rothlisberg, 2001). Economic and social status of the family (Bradley & Corwyn, 2002), parental education (Dubow, Boxer & Huessmann, 2009), the emotional environment at home and the motivation of the family towards the child's education are the essential factors that help the child to make use of his potentials in a maximum productive way. Children of higher status are provided with better amenities and have greater opportunities to come in contact with the first-hand knowledge and more often their homes have a more stimulating environment for learning.

Role of assessment methods in identifying LAS

Hofer and Pintrich (1997) suggested that epistemic beliefs should involve four dimensions: i) "Certainty" of knowledge (e.g. knowledge is fixed or continuously developing), ii) "simplicity" of knowledge (e.g. knowledge is absolute or relative), iii) "source" of knowing (e.g. knowledge is handed down by authority or can be challenged), and iv) "justification" of knowing (e.g. knowledge can be learned from critical thinking processes or from existing facts).

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Research findings have indicated that assessment which encourages students to think for themselves – such as applications to new contexts, and problem-based questions – shifts students in a class towards a deep approach. In contrast, procedures perceived by students as requiring no more than the accurate reproduction of information lead to a predominance of surface approaches (Thomas & Bain, 1984; Scouller, 1998; Psycharis, 2013). For example, a range of research studies has been undertaken to examine the problems that beset the study of mathematics in England. Drawing on some of the most recent studies, they conclude that broadly, four factors influence attainment (drop-out) and achievement. Firstly, a growing culture of performativity in schools; secondly, curriculum content that does not correspond to learner needs; thirdly, progression pathways that do not respond to learner needs; and finally a lack of specialist teachers (Vorderman, 2011; Royal Society, 2011, Norris, 2012). Assessment is an important element of measuring student success when combined with a focus on the process and value of learning itself. However, a culture of performativity in England's schools has become routine with the annual publication of league tables that can detract from focusing on what is best for students. Formative evaluations (portfolios, self- assessment, and peer- assessment) focus on the process of learning and eliminate student's dependency on the teacher figure and consequently lead them to autonomous learning. The way we assess students both formative (i.e. portfolios, self- assessment, peer- assessment etc.) and summative (focusing on measuring the product of the learning process, something that might prove detrimental for student's motivation especially of low achievers resulting in stigmatization) have enormous implications for what we teach and how effectively we teach it. The pedagogical content knowledge (PCK) connects content and pedagogical knowledge facilitating teachers to create an inspiring learning environment for their students. Furthermore, it is both an internal construction of the teachers and an external way to represent how the teacher acts in class and finds reasons for his/her actions. Shulman (1987) included PCK in the "knowledge base of teaching" that consists of three content-related categories (content knowledge, PCK, curriculum knowledge) and four other categories (general pedagogy, learners and their characteristics, educational contexts, and educational purposes) (Valanides & Angeli, 2005). Koehler and Mishra (2008) introduced Technological Pedagogical Content Knowledge (TPACK), which includes relationships and complexities at the intersection of technology, pedagogy, and content.

Role of ICT as a tool for supporting LAS in MST

The Eurydice report, "Key Data in Learning and Innovation through ICT at School in Europe 2011"[1] presents a survey on how ICT is being introduced into the education systems of the EU countries and looks at the specific learning objectives related to ICT use. All countries include at least some of the listed ICT learning objectives in their steering documents for compulsory education. However, these are mainly associated to digital literacy and not Computer Science (CS) as a rigorous academic discipline. The objective (from Eurydice report) that most closely relates to CS is "Developing programming skills" that touches on some aspects of algorithmic reasoning, but does not contemplate the whole content spectrum associated to CS. It is now

[1] http://eacea.ec.europa.eu/education/eurydice/documents/key_data_series/129EN.pdf

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well established that ICT can provide the means to change pedagogical approach from primarily teacher-directed to more student-directed (Pelgrum, 2004). In such pedagogical climate, where the emphasis shifts from being highly cognitive and reproductive to more cooperative, creative and productive, low achievers (usually perceived as cognitively lagging behind) get a chance to experience and show their strengths. So ICT can provide scaffolding means to LAS.

ICT can be also effective for the development of project-based learning and the provision of multiple representations in MST concepts, as well as for the development of collaborative environments. Project-based learning is a method that can be helpful for student's engagement in MST concepts, while it is spread in different countries. In Greece, for example, all students at K-10 are obliged to be involved in project based activities. Moreover, mobile technologies, e-assessment, and virtual learning environments are the most demanding area from the students according to the results of the Survey of Technology Enhanced Learning for Higher Education in the UK (Walker et al., 2014).

Conclusion

According with the second recommendation in the Rocard Report on science education (Rocard et al., 2007), improvements in science education should be brought about through new forms of pedagogy, such as the following: the introduction of inquiry-based approaches in schools, actions for teachers training to Inquiry Based Science and Mathematics Education (IBSE), and the development of teachers' networks. These new forms of pedagogy should be actively promoted and supported in the modern school. The Open Discovery Space (ODS) project is fully aligned with the specific recommendation, and provides support through the numerous communities of practices on the theme of IBSE - for example, the Inspiring Science Education (ISE) Community[2] and the Community on Easy-Java Simulations for Inquiry Based Learning in STEM Disciplines. In this broad context, the paper has explored the application of "threshold concepts" in different learning situations where learners are engaged in key learning processes of Mathematics, Science and Technology.

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Acknowledgment

The part of this work is supported by Open Discovery Space (ODS).The ODS addresses the challenge of modernising school education by engaging teachers, students, parents and policymakers. The full title of this project, funded by the European Commission's CIP-ICT-PSP-2011-5 programme, Theme 2: Digital Content, Objective 2.4: e-learning Objective 2.4, is "Open Discovery Space: A socially-powered and multilingual open learning infrastructure to boost the adoption of e-learning resources".

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

3D PRINTING IN SCIENCE AND ENGINEERING EDUCATION. A BEST PRACTICE: STUDYING, DESIGNING AND 3D PRINTING AN OPERATIONAL MODEL OF A 2100 YEAR-OLD COMPUTER, THE "ANTIKYTHERA MECHANISM"

Georgios Mavromanolakis, Ellinogermaniki Agogi, Theodoros Manousos, Maria Kechri, Panagiota Lida Kollia, Gerasimos Kanellopoulos, Lyceum of Ellinogermaniki Agogi, Greece

Introduction

3D printing technology is an established industrial practice for rapid prototyping and manufacturing across a range of products, components and commercial sectors [1]. It also possesses great potential for every-day life applications to be invented, explored and developed by the coming generations of scientists and engineers [2]. A 3D printer installed in a school setting and complemented by well-designed educational activities can: stimulate the interest and curiosity of students; engage and motivate them into studying science, technology, engineering and mathematics (STEM) subjects, that they may choose or consider as career options; help them to achieve content and concept learning in an innovative way [3,4,5,6]. We developed an interdisciplinary science course for high school students which were implemented in the form of optional educational activity during the school year. The objectives of the course were both to spark the interest and creativity of students and teach them certain curriculum units the content knowledge of which is reached or utilized in an out-of-the-ordinary way. The core of the course is a formidable challenge addressed to students, namely to study, understand, design and build a complex scientific instrument, known as the Antikythera Mechanism, using the 3D printer of their school. In this way a high-tech artefact of the ancient world is linked to a cutting edge technology of the present era, a symbolic link that engages the students that already have strong STEM related interests, but also inspires and motivates those less-interested to explore and develop them. In the following we briefly present the Antikythera Mechanism and then give an overview of the course where we describe its main phases, highlighting also the links to the school curriculum. The paper concludes with a section where the main expected learning outcomes are discussed. Similar educational activities using 3D printing as teaching tool that are under development and will be implemented in the next school year are also reported.

The Antikythera Mechanism

The Antikythera Mechanism (Figure 1) is an extraordinary mechanical device with gears, display indices and dials, constructed in Ancient Greece around the end of the second century B.C. It was found accidentally in 1901 by sponge divers at the bottom of the sea in a shipwreck near the island of Antikythera in Greece. Its complexity astonished, and continues to amaze, the international community of experts and historians on the ancient world as it is technically more complex than any known device for at least a millennium afterwards. Research over the last decades gradually revealed its secrets and decoded its operation and specific functions [7,8]. It is now known that it calculated and displayed astronomical information, particularly cycles such as the phases of the moon, the motions of the sun and the moon across the zodiac along with luni-solar calendars used in ancient times. The mechanism also predicted lunar and solar eclipses and displayed information on periodic events of social significance in the ancient world such as the Olympiad and other important Panhellenic Games. In a nutshell, the device is a mechanical realization of the scientific knowledge and understanding of the cosmos of that epoch. It is internationally known as an artefact of unprecedented human ingenuity and scientific, historic and symbolic value. Since its discovery it has inspired scientists and engineers with its degree of technical and scientific sophistication. Similarly it can stimulate, inspire and engage young students through interdisciplinary educational activities that naturally combine science, technology, engineering and mathematics subjects.

Figure 1. The main fragments of the Antikythera Mechanism as displayed at the National Archaeological Museum of Athens, Greece

Description of the course

The full course consists of 5 phases, discussed below, that total 20 sessions, about 2 hours long each conducted in a weekly basis. It was proposed and started in the school year of 2014-2015 with an announcement/invitation poster to high school students (aged 15-18 years old) to join. Participation is optional and there are no prerequisites or selection in terms of knowledge or skills. The course of this year is offered as an extra-curriculum activity and is taking place outside the regular school time schedule. All the activities and students' work are during the weekly scheduled 2-hour slots and there are no homework or other assignments to be carried out. The actual poster/leaflet posted at the announcement boards of the school is shown in Figure 2, its main message line reads "study, analyse, design and build/3d print an operational model of the Antikythera Mechanism". The leaflet includes also a short description that states that the course is a challenging collaborative project that involves various subject domains from physics, astronomy, mathematics, geometry, informatics, engineering/technology and also history and ancient Greek language! The main challenge is communicated from the start, i.e. the final goal is to build an operational device, and not a static model, that functions like the real instrument. The course quickly attracted the interest of students and a first working group was formed. About two thirds of the participant students have proven STEM related interests and skills, overall half of the group are female students.

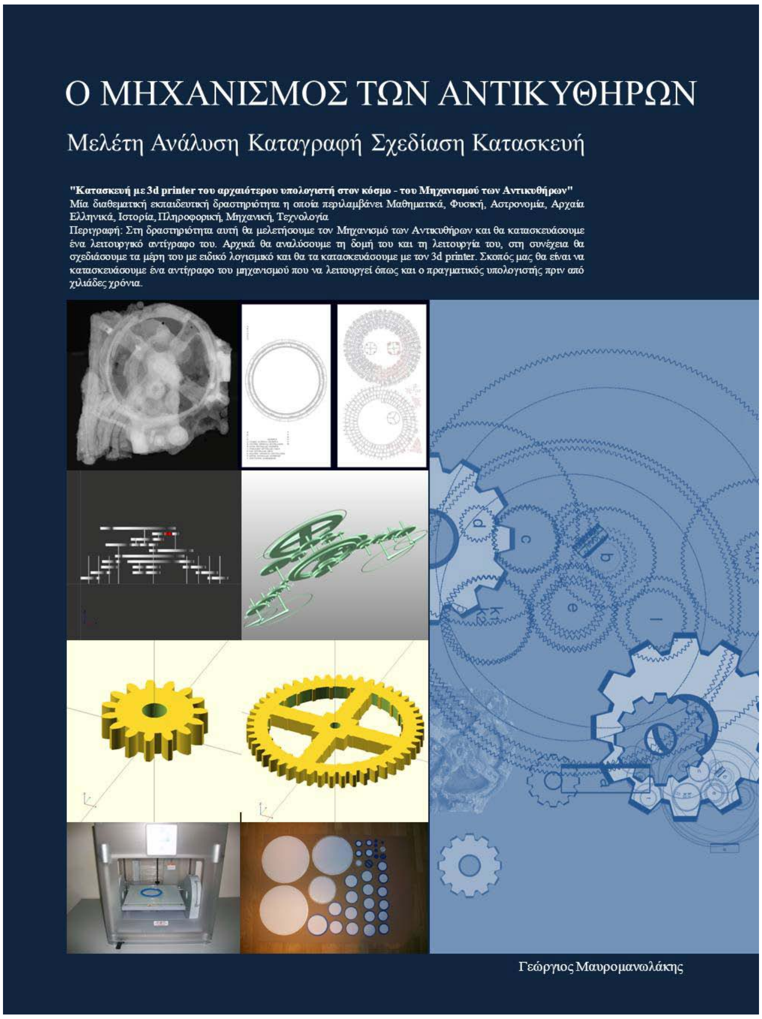

Figure 2. Poster/leaflet about the course distributed and posted at the announcement boards of the school. Its main message line reads "study, analyse, design and build/3D print an operational model of the Antikythera Mechanism"

Phase I – Study and Analysis

In this phase students are given various introductory and informative materials, print and online resources about the mechanism that they have to study in order to gradually understand its components and operation. With the help of the supervising tutors they have as main objective to identify the main elements of the mechanism, i.e. its gears and their relationships. To accomplish this they use free 3D visualization tools of engineering drawings and gear simulation software. They practice their knowledge on maths and geometry related subjects to derive main geometrical parameters and relationships. In order to fully understand

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how a mechanism of gears works they further develop concept and content knowledge of physics curriculum topics like forces, torque, equilibrium, circular motion, through experimentation and inquiry-based simulation resources [9] and well-known applets [10]. Some session time of this phase is devoted to discuss topics from the astronomy curriculum e.g. planets, solar system, stars, etc. This phase ends with a documentary movie about the discovery and investigation of the Antikythera Mechanism along with its historic and scientific implications.

Phase II – Design

During this phase students are learning to use computer-aided-design software to design themselves the components of the mechanism which they will then build with the 3D printer (Figure 3). Free, open-source software is chosen for this purpose (available from www.openscad.org). It offers an integrated user interface for coding, rendering and visualizing in 2D and 3D. Furthermore its basic instructions and commands that students have to use resemble the syntax of a high level programming language, i.e. C++. In this way students practice and further develop their knowledge on informatics related curriculum topics, like code development with variables, functions, libraries, conditional and iteration statements etc. As students are split to work in groups they have to learn to share source code, specifications and design parameters and cross-check each other's work. Most students are very eager to quickly see their designed objects being created by the 3D printer. Thus it is recommended that they proceed to 3D print preliminary draft designs, e.g. see Figure 4, in order to comprehend the transition from the virtual to the real world and have first-hand experience what rapid prototyping means, which are the implications of 3D printing in industrial and commercial applications. During this and the following phases, and depending on progress, there are sessions when a historian/philologist is invited to present to students the social, cultural and political status of the 2nd century B.C. when the Antikythera Mechanism was designed and constructed. With his/her help students also process high resolution images and scans of fragments with inscriptions in ancient Greek language. They decipher words and phrases which survived in their present day native language.

Figure 3. Students working on the design of the gears of the mechanism using open source CAD software

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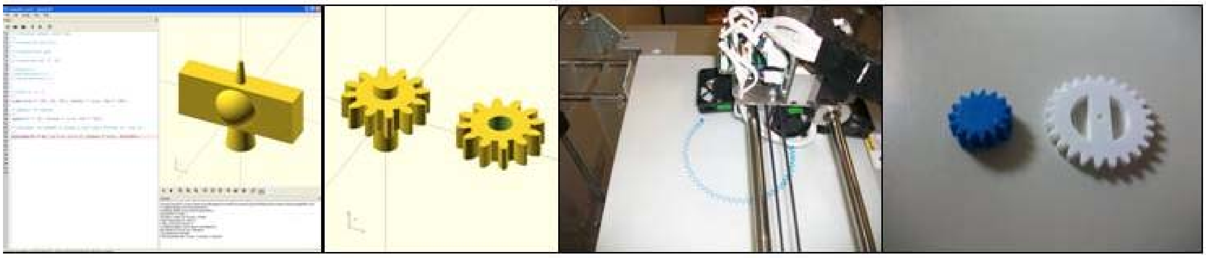

Figure 4. Highlight pictures/photos from the various phases of the course, (from left to right) the openscad user interface, designs of gears, the 3D printer in operation, examples of 3D print-outs

Phase III – 3D Printing

This phase may run in parallel with the design phase. In this phase students "produce" using the 3D printer of the school what they have designed. They may need to go through tests and changes to refine and optimise their designs before they reach final good quality results. As a consequence they experience and understand common engineering processes and what production development cycle means. During this phase they may also investigate what other methods of manufacturing and production they may have used, which are their advantages/disadvantages and associated costs. With the help of the supervising tutors they wonder how a mechanism of such complexity could have been designed and built two decades ago, two hundred years ago, or two thousand years ago. They discuss and reflect on subjects like scientific and technological developments and breakthroughs, impact of science and technology on society, examples and projections from the past to the future, etc.

Phase IV – Assembly

In this phase students proceed to the final assembly of the mechanism (Figure 5). They celebrate the moment where all components are put together and the whole construction is set in motion. They discuss and reflect on all the steps, problems and challenges they have been through and how they resolve them and overcome difficulties. This phase ends with a visit to the National Archaeological Museum of Athens where fragments of the Antikythera Mechanism are displayed (Figure 1).

Figure 5. Students working on the assembly of the mechanism.

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Phase V – Presentation

During this phase students work on making a comprehensive presentation of the project and their experience in order to share it with the school community and the general public. They use the material they have collected and recorded during the previous phases such as photos, videos, drawings etc. They have to compile all the information in a concise report that will be shown in various formats e.g. documentary video, poster or lecture, at science and technology fairs organized by schools and the educational community or other thematic events.

Learning outcomes

In this course high school students are gradually introduced into the 3D printing technology, its applications and potential and are engaged in a challenging collaborative project in which they have to study, analyse, design and build, using the 3D printer of their school, an operational model of a renown ancient artefact, the Antikythera Mechanism. To accomplish this they acquire solid knowledge and understanding by inquiry and practice in a variety of curriculum subjects of physics, astronomy, mathematics, geometry, informatics, engineering/technology and also history and ancient Greek language. During their work they improve their social and verbal skills (collaboration, communication, presentation, project planning and management), develop key competencies (creative learning, innovative thinking, problem solving, cross-disciplinary thinking) and digital literature. They perform tasks like real scientists, researchers and engineers do for their everyday job, and learn and develop similar work practices and attitudes.

Under-development science courses with 3D printer

Similar interdisciplinary educational activities that use 3D printing as a central teaching tool are under development and will be implemented from the coming school year for junior high-school and high-school students, aged 12-15 and 15-18 years old respectively. One activity is about creativity, geometry and maths and its main goal is to capitalize on the direct visualization and instant production of tangible objects 3D printing offers [5,6]. The activity is focusing on the visualization of geometrical patterns, shapes and solids. It also complements the teaching of more abstract concepts, from set theory and mathematical logic, the understanding of which can be greatly facilitated with tangible 3D objects which are studied, designed and produced by the students themselves. Another activity under development is on geography, geology and environmental sciences. A variety of high resolution satellite survey images and data are now publicly available online and can be downloaded freely for educational purposes. Through specialized processing software they can be utilized to create three dimensional maps, which can be 3D printed, of countries and areas of interest that the teachers and their students choose to focus on (Figure 6).

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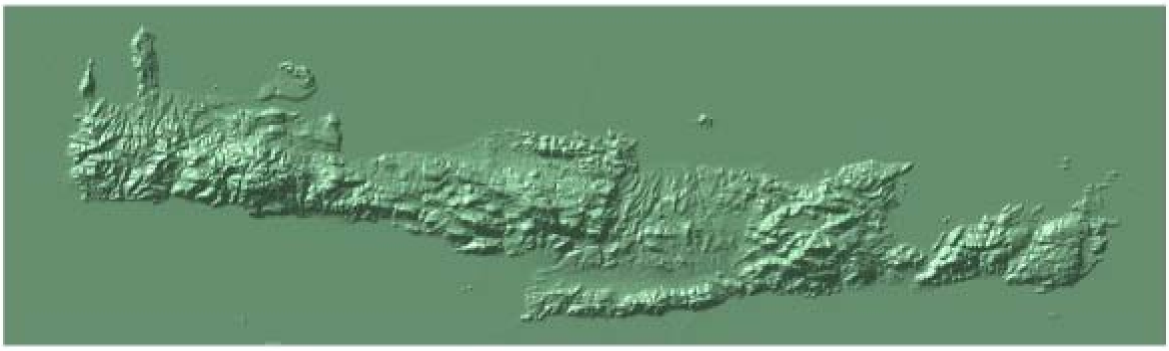

Figure 6. Three dimensional map of the island of Crete created from high resolution satellite survey images. The map can be scaled down and be 3D printed to facilitate the teaching of geology, geography, etc.

Summary

We presented an interdisciplinary science course that was developed for high school students and is implemented in an actual science classroom setting. The objectives of the course were both to spark the interest and creativity of students and teach them certain curriculum units the content knowledge of which is reached or utilized in an out-of-the-ordinary way. Students are gradually introduced into the 3D printing technology, its application and potential and are engaged in a challenging collaborative project in which they have to study, analyse, design and build, using the 3D printer of their school, an operational model of a renown ancient artefact, the Antikythera Mechanism. The course greatly facilitates the teaching of curriculum domains of physics, astronomy, mathematics/geometry, informatics and technology related content and also non-STEM subjects like history and Greek language. We gave an overview of the course, discussing its various phases and highlighting its main outcomes.

ISBN 978-615-5511-06-6

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9. See for example http://www.gearsket.ch
10. PhET, University of Colorado interactive simulations, https://phet.colorado.edu/

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

AN EDUCATIONAL DESIGN-DRIVEN REPRESENTATION METADATA MODEL FOR LESSON PLANS

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Introduction

In the past decade, a large number of digital repositories have emerged towards facilitating teachers to find, access and re-use learning objects (LO) for supporting their daily teaching practice [1]. These repositories offer access to a wide range of educational resources, which are typically characterized using commonly accepted standards and specifications (e.g., the IEEE LOM http://tinyurl.com/obhlpsx [Accessed 20 August 2015]) for allowing transparent capturing of their structural characteristics and facilitating selection and dissemination. However, these representation models are specifically addressed at capturing a narrow content-oriented standpoint of educational resources and thus, only partially facilitate teachers when aiming to capture and disseminate their everyday teaching practice [2]. Therefore, towards addressing the issue of sharing teaching practices and promoting reflective professional development within teachers' online communities of practice, different strands of learning "objects" are exploited which focus beyond strict content-oriented standpoints. One of the most prominent of these strands is "lesson plans" [3].

Lesson Plans (LP) are commonly defined as the detailed description, from a teacher's perspective, of the teaching and learning process for a lesson (i.e., a session of classroom-based flow of teaching, learning and assessment activities) ([4], [5]). In essence, they are document blueprints of a teacher's actions to be performed during the day-to-day classroom teaching practice [6], towards (among others) facilitating the teacher to design, deliver, (self-) post-assess and share their lessons ([5], [6], [7]). Therefore, LPs are commonly used for depicting the core elements of the planned lesson, i.e., the specific educational objectives to be attained, the learning and assessment activities to be delivered, as well as the educational resources and tools that will support the delivery of the aforementioned activities ([6], [7], [8]).

Despite their explicit focus and capacity to capture and disseminate teaching practice LPs have received less attention, compared to LOs, in terms of formulating a commonly accepted representation model that can be used across digital repositories. Furthermore, existing approaches for modelling and representing LPs either do not explicitly capture the internal structural elements of an LP (being more focused on characterizing them as monolithic learning objects, [8]), or they are not referring to a concrete educational design framework [9]. The aforementioned shortcomings provide significant hindrance to both transparently capturing and representing the teaching practice, as well as to effectively disseminating it within teachers' online communities of practices.

In this context, this paper proposes an Educational Design-driven LP Representation Metadata Model (LPRM) which (a) is structured based on the ADDIE Educational Design Model and (b) comprises and extends a range of existing dimensions for modelling LPs. The proposed LPRM aims to provide a means for capturing the internal structure of the LPs in a granulated manner so as to allow for more transparent depiction of lessons. Furthermore, the proposed LPRM aims to facilitate accurate and consistent LPs representation across digital repositories towards more efficient search and dissemination. To achieve this LPRM includes representational elements which are specific for LPs and, thus, offer a higher level of detail in terms of their educational design considerations, compared to the ones depicted for narrow content-oriented LO descriptions.

The remainder of the paper is as follows. The "Background" Section presents the background of this work, namely an overview of existing dimensions for characterizing LPs and a codified depiction of the ADDIE Educational Design model, since both provide the basis for formulating and organizing the proposed LPRM. The "Proposed Educational Design-driven Lesson Plan Representation Metadata Model" Section presents and describes the proposed LPRM. Finally, the paper discusses the conclusions drawn from the paper and presents potential future work.

Background

Existing Lesson Plan Characterization Dimensions

Towards formulating a basis upon which to build the proposed LPRM, this section presents an analysis of 20 existing approaches towards eliciting the dimensions typically used to characterize LPs. The selected references (Table 1) were selected (a) from the scientific literature, (b) from widely used practice-oriented websites, which focus on storing and disseminating LPs, and (c) from commonly used LP authoring tools (AT) exploited by teacher practitioners for planning their daily teaching practice. Such diversity in the sources was deemed important in order to capture their (potentially) different standpoints to LP characterization. Upon retrieval of these sources, a content analysis was performed in their LP representation approaches in order to elicit the specific dimensions they exploited.

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Table 1: References used for eliciting Existing Lesson Plan Representation Dimensions

#	Reference	URL
1	[10]	-
2	[11]	-
3	[12]	-
4	[9]	-
5	[8]	-
6	[13]	-
7	Hot Chalk Website	http://tinyurl.com/q7b7edg
8	Education Oasis Website	http://tinyurl.com/ps35xcl
9	TES-Connect Website	http://tinyurl.com/pg4j8ac
10	ArtsEdge Website	http://tinyurl.com/ol6rx79
11	PBS Learning Media Website	http://tinyurl.com/qj3utd6
12	Illuminations Website	http://tinyurl.com/p3shxyk
13	American Association for Advancement of Science Website	http://tinyurl.com/p7a74bu
14	Common Curriculum AT	http://tinyurl.com/dx2jzj8
15	Utah Education Network AT	http://tinyurl.com/plmu5da
16	PlanBoardApp AT	http://tinyurl.com/cg2o8g9
17	PlanBookEdu AT	http://tinyurl.com/ygqtr7o
18	Learnboost AT	http://tinyurl.com/ot94f2b
19	Teach - nology AT	http://tinyurl.com/kpu3xd
20	My Lesson Planner AT	http://tinyurl.com/qjvwo8z

Table 2 presents the results of the aforementioned content analysis process, i.e., the superset of the elicited representation dimensions for LPs. As aforementioned, this superset is exploited in the present work in order to provide the foundational dimensions which the proposed LPRM adopts and adapts (based on the considerations introduced by the ADDIE model, which will be presented in the next section).

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Table 2: Existing Lesson Plan Representation Dimensions

LP Representation Dimensions	References																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Title	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2. Author				✓					✓	✓	✓	✓		✓	✓	✓		✓	✓	✓
3. Summary		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓				✓	
4. Keywords				✓	✓				✓						✓			✓		✓
5. Educational Problem	✓		✓					✓							✓					
6. Grade Level	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
7. Duration				✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
8. Subject Domain	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
9. Subject Domain Topic							✓		✓	✓		✓		✓				✓	✓	✓
10. Educational Standards			✓		✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
11. Educational Resources –Tools		✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
12. Teachers' Prerequisite Competences				✓						✓					✓					
13. Students' Prerequisite Competences				✓	✓				✓	✓	✓	✓			✓					
14. Student Accessibility Issues			✓	✓					✓	✓					✓				✓	
14. General Educational Objectives Addressed				✓		✓	✓			✓	✓	✓		✓	✓				✓	✓
15. Specific Educational Objectives Addressed	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
16. Teaching approach		✓		✓	✓	✓				✓										✓
17. Flow of Learning activities	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
18. Flow of Assessment Activities	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
19. Assessment Method / Type Utilized										✓										✓
20. Teacher Reflection and Lesson Adaptations	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓

As the Table 2 depicts, a clear set of recurring dimensions for representing LPs can be identified. More specifically, among the highlighted superset of 20 dimensions, a "cluster" of 12 commonly used dimensions can be highlighted, i.e., the dimensions with occurrence frequency above 50%. As this subset of LP representation dimensions reveals (Figure 1), the majority of the existing approaches focus on facilitating teachers to capture specific aspects of their teaching practice, potentially useful for providing them with a guide to deliver their day-to-day lessons. This is consistent with the characteristics of LPs provided in the "Introduction" Section, i.e., that LPs are primarily focused at describing a strict set of lesson dimensions from a teacher's perspective.

Moreover, other dimensions such as (a) the "Educational Problem" (x=20%), (b) the "General Educational Objectives" (x=50%), (c) the "Teaching Approach" (x=30%) and (d) students' and teachers' prerequisite competences (x=35% and 15%, respectively), are more rarely supported. This further supports the previous argument, since these dimensions have a more general educational description scope (i.e., extending the "narrow" scope of capturing teachers' own day-to-day teaching practice). Thus, this is another indicator that existing approaches to characterizing LPs are more focused on supporting individual teachers to plan their *own practice*, with limited accommodation of dimensions that would facilitate

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transparent dissemination to other practitioners (e.g., the required students' / teachers' competences).This, however, can prove a hindering factor when the LPs are described and disseminated within a teachers' community, since these dimensions can directly impact the capacity of a teacher to re-use a specific LP in their own context and setting.

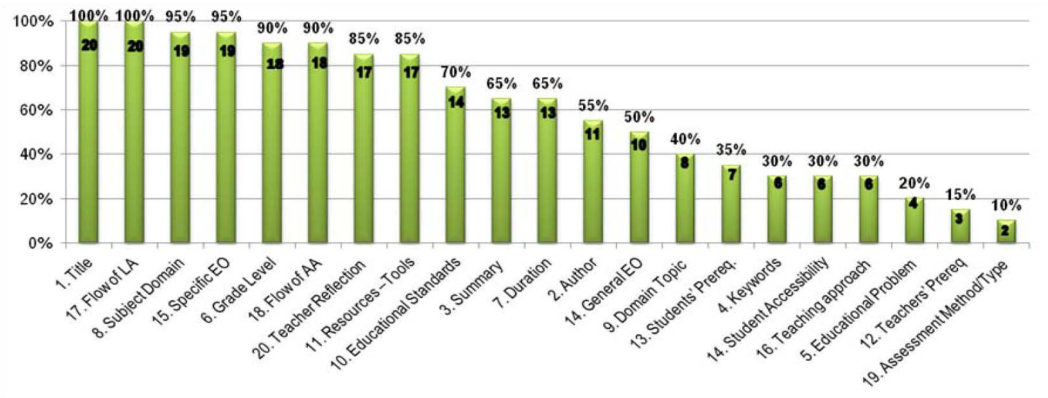

Figure 1. Occurrence Frequency of existing Lesson Plan Representation Dimensions

Under this light, the contribution of this paper is to formulate a detailed Educational Design-driven Lesson Plan Representation Metadata Model which aims at capturing the full superset of the identified LP representation dimensions, further adapted to accommodate the considerations of the ADDIE Educational Design Model. Towards that end, the ADDIE Model is analyzed in the following section in a codified manner.

ADDIE Model of Educational Design

The ADDIE model is a framework towards driving the systematic Educational Design (ED) process [14]. This fundamental ED model is a process comprising five Phases, namely Analysis, Design, Develop, Implement and Evaluate. These phases are carried out iteratively throughout the life of an ED product [15]. A structured depiction of the aforementioned ADDIE Phases, each analyzed to its constituent elements, is presented in Table 3.

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ISBN 978-615-5511-06-6

Table 3: Codified Depiction of the ADDIE Educational Design Model

ADDIE Phase	ADDIE Sub- Phase	Description
Analysis	A1. Educational Problem Identification	Includes identification of the rationale supporting the need for an educational intervention
	A2. Contextual Analysis	Aims to capture (a) infrastructure-related issues concerning the place the educational intervention will be held, (b) the duration of the educational intervention, and (c) competence profiling elements for the teacher/instructor
	A3. Learner Analysis	Includes the analysis of the characteristics of the (groups of) learners who will engage in the educational intervention.
Design	DES1. Definition of Educational Objectives	Includes the definition of general and specific educational objectives for the educational intervention and their mapping to existing (inter-)national curriculum standards.
	DES2. Selection of Teaching Approach/Strategy	Includes the selection of an appropriate teaching approach/strategy for supporting learners in attaining the educational objectives. It also includes the preferred flow of the teaching, learning and/or assessment activities according to the selected teaching approach/strategy and their mapping to the educational objectives that they address
	DES3. Selection of Assessment Method(s)	Includes selection of appropriate assessment methods for evaluating the attainment of the educational objectives. This includes also preferred flow of the assessment activities according to the selected teaching approach/strategy and assessment method(s).
Develop	DEV1. Development or selection of educational resources	Includes the formulation of new or selection of pre-existing educational resources, capable of supporting the teaching, learning and/or assessment activities of the Design Phase.
	DEV2. Development or selection of educational tools and/or services	Includes the formulation of new or selection of pre-existing educational tools and services, for supporting the teaching, learning and/or assessment activities of the Design Phase.
	DEV3. Development / arrangement of the appropriate delivery setting	Includes the development / selection or alteration of the setting in which the designed educational intervention will be delivered.
Implement	I1. Delivery	Includes the delivery of the product from the previous three phases to the learners.
	I2. Monitoring	Includes tracking of learners' actions, collecting and analyzing meaningful educational data based on which teachers can form evidence-based reflections on the delivery.
Evaluation	E1. Formative Evaluation	Includes an ongoing evaluation process during design, development and implementation phases and aims to maximize pedagogical / andragogical effectiveness (e.g. achievement of educational objectives) and/or implementation efficiency (e.g. time/cost reduction).
	E2. Summative Evaluation	Includes measuring pedagogical / andragogical effectiveness (e.g. achievement of educational objectives) and/or implementation efficiency (e.g. time/cost reduction) of the ED after completion.

This detailed and codified depiction of the ADDIE Educational Design Model in used to provide the backbone framework upon which to extend the existing dimensions used to represent LPs towards the formulation of the proposed Educational Design-driven LP Representation Metadata Model. This process and the resulting LPRM are presented in the following section.

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Proposed Educational Design-driven Lesson Plan Representation Metadata Model

Based on the findings of the two previous sections, Table 4 presents the proposed Educational Design-driven LPRM. As aforementioned, the LPRM aims at explicitly capturing the internal structure of LPs along with additional general metadata elements towards providing a highly granulated manner of representing LPs and allowing for more effective dissemination of the teaching practice. In order to populate specific dimensions of the LPRM with a "closed vocabulary" value space, the existing taxonomies of a major European project, namely Open Discovery Space (ODS) [http://www.opendiscoveryspace.eu] were exploited. The use of closed vocabularies for a wide set of representational dimensions, was decided in order to support the capacity of the LPRM to be used within digital repositories of teachers' online communities, as a method to potentially enhance storing and searching capabilities for LPs.

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Table 4: Proposed Educational Design-driven Lesson Plan Representation Metadata Model

ADDIE Phase	Representation Element	Description	Value Type
General Metadata Elements	Title	The title of the lesson	LangString
	Summary	A summarizing description of the lesson	LangString
	Author	The teacher who designed the lesson	LangString
	Keywords	Keywords describing core aspects of the lesson	LangString
	Copyrights	Potential copyright restrictions for the lesson	CC Licence
A1.	A1. Educational Problem	The educational problem that the lesson is addressing	LangString
A2.	A2.1 Duration	The expected duration of the lesson (in hours)	Numerical
	A2.2 Teacher's Competences Background	Pre-requisite teachers' competences for delivering the lesson	UNESCO Framework[1]
	A2.3 Required Infrastructure	The technical / physical infrastructure for delivering the lesson	LangString
A3.	A3.1 Typical Age Range	The appropriate age range of the students	Numerical
	A3.2 Language	The language of the lesson to be delivered	ODS Taxonomy[2]
	A3.3 Students prior Competencies	Potential pre-requisites in terms of students' competences	LangString
	A3.4 Accessibility Features	Potential accessibility needs of the students	ODS Taxonomy[3]
DES1.	DES1.1 Subject Domain	The subject domain(s) of the lesson	ODS Taxonomy[4]
	DES1.2 Topic Domain	The subject domain topics of the lesson	
	DES1.3 General Learning Outcomes	The general and specific educational objectives addressed in the lesson. Each educational objective should be "codified" (i.e., be assigned a unique decimal ID) in order to allow for referencing from other elements (e.g., teaching/learning/assessment activities)	ODS Taxonomy[5]
	DES1.4 Specific Educational Objectives		LangString
	DES1.5 Educational Curriculum Standards	Specific (Inter)National educational curriculum standards (such as Common Core) addressed	LangString
DES2.	DES2.1 Teaching Approach	The teaching approach utilized in the lesson	ODS Taxonomy[6]
	DES2.2 Flow of Teaching / Learning / Assessment Activities	The flow of teaching / learning / assessment activities in the lesson and their mapping to specific educational objectives. The flow of teaching / learning / assessment activities and their mapping to the educational objectives is performed in a **tabular** form. Each row of the table includes the description of one teaching / learning / assessment activity and is complemented (in separate columns) by its unique ID code –incremental decimals- and the ID of the educational objective is supports)	LangString
DES3.	DES3.1 Assessment Type(s)	The assessment type(s) used in the lesson (e.g., diagnostic assessment, summative assessment)	ODS Taxonomy[7]
	DES3.2 Assessment Method(s)	The assessment activities and method(s) used in the lesson, i.e., the description of the assessment activities of the lesson and the method of assessment used in each one (e.g., Multiple Choice quiz, Debate etc). These aspects are incorporated in the Table used for DES2.2 (i.e., the assessment activities are embedded in the existing flow of learning activities along with their aforementioned attributes in separate columns)	LangString
DEV1.	DEV1. Educational Resources	The educational resources exploited in the lesson mapped to specific teaching / learning / assessment activities. These aspects are incorporated in the Table used for DES2.2 (i.e., by incorporating additional columns for each teaching / learning / assessment activity)	LangString
DEV2.	DEV2.1 Required Educational Tools	The educational tools and services exploited in the lesson mapped to specific learning/assessment activities	LangString
	DEV2.2 Required Services		LangString
DEV3.	DEV3. Development / arrangement of the appropriate delivery setting	Potential arrangements / alterations of the physical space in order to effectively support the needs of the lesson	LangString
I1. - I2. - E1.	-	These elements are not captured in the LPRM because they are related to the *delivery* of the lesson	-
E2.	E2.1 Adaptations/ Extensions	Potential alterations proposed by the teacher based on educational data and/or experiences collected in prior deliveries. The description of these alterations are introduced in a "free-text" format, and the unique IDs of the teaching / learning / assessment activities can be referenced in order for the teacher to specifically address the part of the lesson in which adaptations/extensions were made.	LangString
	E2.2 Teacher's Reflection	Reflection focusing on the evaluation results of both the students as well as the lesson (provided by the students). The manner of the depiction of the teachers' reflections are introduced similarly as in E2.1	LangString

[1] http://tinyurl.com/7w7mshf, [2] http://tinyurl.com/qju4h7n, [3] http://tinyurl.com/nal4hb8, [4] http://tinyurl.com/pc9ja6d, [5] http://tinyurl.com/ow4m3w9, [6] http://tinyurl.com/oroge5g, [7] http://tinyurl.com/qdeyowg

ISBN 978-615-5511-06-6

As the Table 4 depicts, the proposed LPRM comprises a superset of the identified existing LP representation dimensions, but also extends them following the requirements of the ADDIE Model towards providing a detailed representation model for LPs. More specifically, the LPRM accommodates the "required" characteristics of LPs (as defined in this paper) towards allowing individual teachers to robustly depict their private teaching practice. Furthermore, it takes a step beyond that, by incorporating representational dimensions aiming to captivate elements of the lesson design that can greatly affect its delivery, such as the required teacher competences, the infrastructural requirements and the prior (possibly collective) experiences and adaptations of the teacher(s) that have already delivered the lesson within particular contexts (which are also captured in the LPRM).

The latter added value of the proposed LPRM is especially significant when considered in the context of teaching practice dissemination within teachers' online communities, because potentially interested teachers should be able to select a "good practice" on a conditional manner, i.e., by explicitly considering i) the detailed description of the teaching practice itself, but also ii) the context in which the teaching practice was performed, and iii) the reflections on / outcomes of the practice within this particular context. Such a highly granulated depiction can allow teachers to retrieve (and re-use) those LPs that are not only relevant to their subject domain knowledge-related needs, but have also been successfully delivered and "reviewed" in contexts and educational settings similar to their own.

Conclusions and Future Work

This paper originated from the need for a common and granulated way to transparently depict the teaching practices occurring within the classroom "black box". By using the concept of LP as a means to capture and disseminate these practices, a lack of a common approach to represent LPs was identified. Moreover, existing approaches to address this issue were either not focusing on capturing the internal structural elements of LPs, or they were not based on a concrete educational design framework towards ensuring that the LP would be adequately represented from an educational design perspective.

Under this light, this paper presented an Educational Design-driven Lesson Plan Representation Metadata Model, which aims at addressing the aforementioned shortcomings by i) exploiting a superset of existing dimensions for representing LPs from both the scientific literature as well as from practice-oriented standpoints and ii) appropriately structuring and extending this superset based on the considerations imposed by the ADDIE Educational Design Model. The proposed Educational Design-driven LPRM has the potential to facilitate transparent depiction of the internal structure of LPs and also allow for more effective practice dissemination within teachers' online communities by providing access to a wider set of data for evaluating the appropriateness of each LP for each teacher's own specific educational setting, competences and students' capacities.

Future work could include an evaluation of existing LP authoring tools in terms of the level of accommodation they offer for the proposed LPRM. This evaluation process could lead to the

ISBN 978-615-5511-06-6

identification of shortcomings in the capacities of the existing LP authoring tools towards captivating the full spectrum of the LP representational dimensions. Furthermore, based on the results of this critical analysis process, LP authoring tools which will fully incorporate the proposed LP Representation Metadata Model could be designed and implemented, thus allowing for transparent depiction and dissemination of the teaching practices within teachers' communities of practice.

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Acknowledgement

The work presented in this chapter has been partly supported by the Inspiring Science Project that is funded by the European Commission's CIP-ICT Policy Support Programme (Project Number: 325123). This document does not represent the opinion of the European Commission, and the European Commission is not responsible for any use that might be made of its content.

ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

CO-DESIGNING DIGITAL GAMING ACTIVITIES TO FOSTER CO-CREATIVITY IN LEARNING

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Games for co-creativity in European schools: overview of the C2Learn project

C2Learn (www.c2learn.eu) is a European research project (2013-2015) aiming to foster co-creativity in learning through digital gaming activities whose design and development is grounded on rigid theoretical foundations. Current understandings of creativity in education and creative thinking meet with digital games and intelligent technologies to provide young learners and their teachers with innovative opportunities for *co-creativity* in learning. The project aims at producing tangible research-based outcomes readily available for use in and outside classrooms. Therefore it is shaped as a progression from theoretical foundations to design, development, pilot implementation and evaluation in real life educational settings. Careful pedagogical and game designs have defined the elements of learners' gameful digital experiences and produced the specifications for the development of the corresponding technologies and activities. In this process and throughout the project, school communities have been engaged in iterative dialogic cycles leading to design decisions, their implementation and evaluation in real-life educational settings. This paper presents in summary the methodology followed and the results of a core part of the research, which was conducted in primary and secondary schools in Greece.

C2Learn theory and pedagogy

The foundations of the project lie in a consolidated theoretical framework encompassing the theories of Wise Humanising Creativity (WHC) [1], [2], [3] and Creative Emotional Reasoning (CER) [4]. C2Learn theory provides insights into how co-creativity of children and young people can be fostered in formal and informal learning settings. Co-creativity is defined as educational activity in which learners, individually as well as mainly collaboratively and also communally, come up with novelty, new ideas. These new ideas: a) have emerged through asking 'what if' and 'as if' questions and through the use of disruptive techniques resulting in re-framing; b) have emerged from shared ideas and actions in an immersed dialogic rather than hierarchical pedagogical environment; and c) are captured or selected because they matter to the community and have a valuable impact on it. In this, learners take into account the impact of that novelty on the individual, collaborative and communal dimensions of their community.

The theoretical framework defines the vision of the project and frames the design and development of the envisioned C2Learn technological solution. C2Learn theory also defines the wider conceptual and pedagogical framework in which the use of C2Learn technologies and C2Learn-inspired learning and teaching practices are placed. Thus, starting from C2Learn theory, the project produces theoretically framed technological innovation combined with designs for its deployment, use, and evaluation in real educational practice.

C2Learn theory is provided to the project in an operational form so that it can be used for the design and evaluation of the C2Learn solution. Thus, the theoretical framework is manifested as: a) CER Techniques [4] [5], which offer ways for the application of CER in practice; b) Learning Design [6] [7], which describes how WHC and CER can be enacted in pedagogical practice; and c) co-creativity assessment methodology [8], which is used in the pilots to establish to what extent and in what ways the solution produced by the project has the desired effect.

C2Learn technology and gameful design

The technology produced is an innovative digital gaming and social networking environment incorporating diverse tools the use of which can foster co-creativity in learning processes in the context of both formal and informal educational settings. Digital gaming constitutes the chosen means for the involvement of learners and educators in WHC-CER practices in and around this digital environment. C2Learn theory thus frames game design, so that the designed playful digital experiences can foster co-creativity as theorized in C2Learn.

The C2Learn digital environment and the wider pedagogical environment in which it is used are gameful environments where co-creativity occurs playfully. The pursuit of playfulness is a priority served through explicit gameful design [9] [10]. In addition, background Artificial Intelligence (AI) technologies are employed to further empower learners as creators and creative thinkers within the defined frame of co-creativity.

Co-designing and piloting with school communities

Throughout, school communities are actively engaged in iterative dialogic cycles leading to design decisions, their pilot implementation and evaluation in classrooms. In close reflective collaboration with communities of educators and students in Austria, Greece and England, researchers gather user requirements, co-design locally appropriate solutions for the introduction of the innovation in real life learning settings, negotiate and plan various instances of such an introduction for the purposes of piloting and evaluation.

The aim of piloting in the project is to test and evaluate with users the C2Learn experience, including both the technologies developed and the pedagogical practices enabled by these technologies. In the pilots, educational activities specifically shaped around the use of the C2Learn technologies and methodologies are implemented in educational settings. The aim is to create conditions for evaluation that can provide the project with feedback used for further refining design and development and for introducing adjustments and improvements.

ISBN 978-615-5511-06-6

Evaluation is realized through the application of the co-creativity assessment methodology specifically developed on the basis of C2Learn theory. The core aim is to evaluate C2Learn's impact on learner's co-creativity as theorized in the project, by documenting change as well as the lived experience of engaging in C2Learn-enabled activity [8]. The co-creativity assessment methodology is applied in fieldwork during the pilots leading to the collection of rich qualitative data, . The data collected is then analysed to lead to critical descriptions of the activities, evaluative findings and conclusions.

Educational scenarios: orchestrations of experience

Educational scenarios [11], [12], [13] provide the integration of the various parts of the project into a coherent C2Learn user experience in a given educational setting, orchestrating the various technological and pedagogical parts of the project described in the previous sections. They are concrete designs of pedagogical practice in the context of given educational settings specified in terms of learner age group, curriculum links, the degree of formality of the learning activities, and the wider cultural/country setting. Educational scenarios thus 'translate' learning design and game design into plans for the implementation of educational activities in real life, predominantly in the pilots run within the project, but eventually also in other educational settings. At the same time, scenarios present the world of education with the range of possibilities offered and examples of effective use of the C2Learn solution.

Educational scenarios are designed in close collaboration with the school communities, providing input into the design process directly from educational practice. Indeed, they constitute that aspect of the design of the C2Learn solution which is most strongly shaped by the collaborating school communities and framed by their educational realities. They are a design tool aiming to ensure that the innovative technologies deployed and practices introduced will correspond to the needs, circumstances, expectations and aspirations of the end users. Therefore, their development is interwoven with processes aiming at establishing user expectations and requirements.

A scenario-based design approach

As we have described elsewhere [14], setting out from a theoretical perspective and motivation, the project has deliberately adopted a scenario-based approach to engage teachers as designers of learning experiences. In summary, in our approach a scenario is an adequate but flexible structure for sustained engagement and learning within open-ended environments, like the ones designed in C2Learn. In addition, scenarios can also enable teachers to manage the change in the flow of classroom activity induced by the technology-enhanced pedagogical innovation. Further, by shifting the pedagogical emphasis from the transmission of subject matter to the orchestration of experiences around the subject matter, C2Learn scenarios focuses on a crucial dimension that is often neglected in discussing the curriculum: making the learning situation meaningful from the point of view of the students. Scenarios can turn our curricular objectives into personal goals that students understand and embrace. Finally, scenarios can generate useful user input to inform the design of the envisioned technological system, as well as serving as exemplars for communicating

ISBN 978-615-5511-06-6

pedagogical innovation to a broader population of potential users and other communities of interest.

Scenarios maturing throughout

Educational scenarios serve different purposes in the course of the project, gradually maturing together with the project approach. They have been developed in three main iterations, while they remain open to elaboration and refinement throughout the project.

In the very early stages, scenarios [11] started as short narratives illustrating possibilities meaningful to users, aiming to present a range of potential directions without being prescriptive. Those early scenarios provided initial ideas for C2Learn activity and contributed to an understanding of user requirements and the given educational settings. Later on in the first project year, the original scenario ideas were critically examined and selected scenarios were further elaborated [12]. From the second project year onwards, as learning design and game design have produced mature outputs, educational scenarios are being transformed from open and generic ideas into concrete use cases, i.e. detailed designs of C2Learn experience in given educational settings [13]. At this stage, scenarios are framed by the educational realities in the collaborating school communities, and inform the project about the pragmatic context of the pilots. In this sense, they are also becoming important input into technology development and integration, shedding light on pragmatic restrictions and priorities.

The above described procedure applies to the use of educational scenarios as tools used to frame and shape the pilot activities in the project. In the long term, educational scenarios are provided to teachers and learners as open-ended tools encouraging them to develop their own designs of C2Learn activity, outside the pilots and beyond the end of the project. This use of educational scenarios entails the development of detailed non-prescriptive guidelines to learners and educators for the use of the C2Learn solution, including ideas and examples of effective use originating from the pilots. In this sense, the educational scenarios gradually evolve into an integral part of the final C2Learn solution, accompanying the digital products.

Scenarios as instantiations of the C2Learn pedagogical environment

Throughout the project and at all stages of their maturity, educational scenarios place the pedagogical and technological aspects of C2Learn experience in the frame of the C2Learn pedagogical environment, describing certain instantiations of this pedagogical environment. All aspects of C2Learn pedagogical practice defined through learning design are represented in educational scenarios. Each scenario constitutes a concrete design for the orchestration in a given educational setting of the elements and time-frame of C2Learn practice as described in sections 2 and 3 above.

An important aspect of this design is the distribution of C2Learn practice in the physical and digital spaces of C2Learn. In this context, educational scenarios propose appropriate configurations of the use of digital and non-digital C2Learn assets in the pedagogical

Transforming Schools into Innovative Learning Organisations
EDEN Open Classroom Conference Proceedings, 2015, Athens
ISBN 978-615-5511-06-6

environment, based on the affordances and opportunities offered by the various media and how those can be best used in a given educational setting. Thus, they describe activities which include, but are not limited to, the use of C2Space and C2Experiences. In particular, while game design proposes the ways in which a particular C2Experience is integrated into C2Space, educational scenarios come to shed light on the pedagogical uses of these technological assets in the context of educational activities in the wider pedagogical environment. In doing so, they also exploit and further develop ideas generated through game design for the gameful design of the wider pedagogical environment through non-digital means.

Attention is paid to the representation in the scenarios of a wide variety of configurations of C2Learn experience, including the use of different combinations of digital and non-digital assets, in various time frames, so as to illustrate the versatility, flexibility and adaptability of the C2Learn solution. Each educational scenario includes at least one core episode of co-creativity, while some scenarios may constitute series of core episodes spanning over shorter or longer periods of time, realizing longer-term reflection-oriented experiences. Similarly, the scope of a scenario may vary from describing the application of a single C2Experience in context, to complex orchestrations of various C2Experiences and non-digital activities.

Concluding reflections on co-designing with teachers

Developing educational scenarios in C2Learn together with teachers has been a rich and rewarding experience for the teams of researchers involved. Here we summarise some of the important lessons learned and interesting questions arising from this experience [14].

We have considered the degree of formalism which is desirable in scenario templates provided as design tools for teachers. It is important to strike a balance between capturing scenarios at the desired level of detail in a common standard format, on the one hand, and avoiding the over-proceduralizing and overformalizing that kills the creativity of teachers and by extension of students, on the other. The goal is to have a framework that is simple, easy to use, transparent and allows for adaptation and variation, so that the researchers in collaboration with the user communities can capture all aspects that they consider important.

Another important issue that arose in our work is the relation between designing a game scenario and designing a scenario for orchestrating game-based learning. To some extent, these design processes overlap while also being different, and defining how teachers should be involved in them can become a challenge. Discussions with teachers often tended towards proposing designs for a digital game, and narrowing the design considerations to a technological solution. Further, there is the risk of equating playful learning with gaming, whereas we should always be mindful that digital games are only a subspecies of play and guard against elevating digital games to the predominance at the expense of other play forms that engender creativity and learning.

A further consideration that emerged is whether and to what extent game-based learning scenarios should be following the curriculum. Thinking too much in terms of circumscribed units of knowledge and skill corresponding to lesson units may result in forcing aspects of the

ISBN 978-615-5511-06-6

curriculum into a game that cannot be well integrated into it and in missing opportunities to use games for fostering creativity. Instead of trying to incorporate the curriculum into a game, we may want to experiment with scenarios where players encounter challenges that are related to but broader than the curriculum in order to capture the special potential of games for learning and especially for fostering creativity.

Finally, introducing innovation in education requires a shift in practice and approach that cannot be effected top-down, but needs to include teachers. Nevertheless, teachers often do not have working models for the proposed innovation. The ideas and vocabulary used by researchers often seem far removed from their practice. As a result, though they are included as co-designers, when it comes to innovative concepts and not merely designing educational technology to meet given curricular objectives, a common language is hard to develop. We propose that a scenario-based approach can bridge this language gap to a great degree, but we are also mindful that careful elaboration and refinement of this approach is needed, lest it produces an obscuring language of its own.

Acknowledgments

The C2Learn project (November 2012 – October 2015) is supported by the European Commission through the Seventh Framework Programme (FP7) under grant agreement no. 318480. The contents of this paper do not represent the views of the European Commission and the Commission cannot be held responsible for any use which may be made of the information contained therein. Responsibility for the information and views set out in this paper lies entirely with the authors.

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Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

SPECTRA – LESSON PLAN

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Brief Description

The purpose of this lesson is for students to acquire information about the electromagnetic spectrum and how its interpretation enables scientists to gather information about the universe. Moreover, students will observe other spectra with their self-made spectroscopes made from everyday materials. They will attempt to classify them so as to realise their utility as material – identifiers. Provided with an interactive and flexible learning environment, students will be allowed to follow their curiosity and to learn at their own pace.

Subject Domain

Spectrum of electromagnetic radiation, types of spectra, white light analysis, parts of the electromagnetic radiation spectrum

Keywords: Optical spectra, emission-absorption spectrum, light source, prism, energy levels, electrons, H- Alfa line.

Age Range: 16-18.

Didactical Hours: 3 didactic hours.

Educational Objectives

The light and the spectrum

- To learn the optical spectrum and its parts.
- To be able to describe the electromagnetic spectrum.
- To be able to describe how electromagnetic radiation exists beyond what we can see with our eyes.
- To be able to describe how different regions of the electromagnetic spectrum (such as ultraviolet, visible, infrared, radio) correspond to specific wavelengths and frequencies of electromagnetic waves.

Types of optical spectra

- To learn the continuous, emission line and absorption line spectra.
- To be able to describe the information that can be obtained from the study of the continuous spectrum of luminous solids or liquids.

Spectra and spectral types of stars

- To learn the reason for the classification of stars by spectral types.
- To be able to describe the information obtained through studying the stellar spectra.
- To be able to describe the basic spectral types of stars.

Physical Layout of Room

Teachers may decide whether students work in small groups of two or three, or individually. No more than 3 students should share a computer in order to maximize learning. Adaptations can be made to accommodate classrooms with one computer with Internet access. These might include using an overhead projector with a LCD that projects the computer image on a screen or a hook-up from a computer to a television monitor.

Orientation

Firstly students will be asked to watch parts of the following video http://www.youtube.com/watch?v=nbtS_cWaISE so as to realize the importance of spectra and the reason why we need to study them.

Secondly they will make their own spectrometer/spectroscope by watching one of the following videos according to the materials at hand.

Figure 1. http://www.youtube.com/watch?v=fl42pnUbCCA

Figure 2 http://www.youtube.com/watch?v=YStZk2zANvk

Thirdly, students will be asked:

1. How do scientists study stars and planets?
2. What instruments do they use in order to determine what a planet or a star is made from?

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Conceptualization

Sub-phase: Hypothesis

Step 1

Let's see what we have learnt about light! (previous lessons)

1. What is light? (an electromagnetic wave)
2. How fast does it move? (it moves with extremely high velocity ,in the vacuum the velocity of light is almost 300000Km/sec).
3. What is a wavelength, what does it define? (the length between two peaks of the wave is called a wavelength. The colour of the light depends on the wavelength.)
4. How do we get white? (If we combine all the colours together, we get white light, which is called visible.)

Let's see what we already know about spectra!

1. What does a prism do to white light? (a prism "disentangles" white light and separates all the colours out)
2. How is a rainbow formed? (Raindrops can act as a prism. Each raindrop breaks up and reflects the light from the sun).
3. Is the electromagnetic spectrum the same as the visible light spectrum (can we see all the parts of the electromagnetic spectrum)? (no The electromagnetic spectrum is divided into the visible part, which we are able to see, and the invisible which forms the greater part like radio waves, infrared, visible, ultraviolet, X-rays and gamma-rays – radiation emitted in nature).
4. Are all spectra the same? What does the form of electromagnetic spectrum emitted from a light source depend upon? (The form of electromagnetic spectrum which is emitted from a light source depends upon the type of the source and the conditions under which the emission takes place).
5. What do you know about the light emitted by celestial bodies? (All celestial bodies that give out light emit rays at a large part of the electromagnetic spectrum (visible and invisible) and according to their surface temperature they emit rays to mainly one area of the spectrum. However, all these electromagnetic waves do not reach us. The earth's atmosphere can be penetrated only by rays which are in the visible spectrum, in a section of the infrared and the radio wave area.) Indeed spectra is the key to understanding the Universe.

Answers are for teacher – use only. Do not point out any mistakes students might make. Students are supposed to discover these mistakes themselves and correct them. Alternatively, you may note them down and bring them back to their attention at a later stage.

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Create a concept map: Write down all the concepts, you believe, are connected to spectra. Use arrows to interconnect the different concepts and explain how they are connected to each other.

Step2:

Scientists are able to study phenomena due to the existence of certain scientific instruments such as the spectrometer and telescopes. In order to investigate these phenomena they also use simulations. We will now put ourselves in the position of amateur scientists. Our work includes two main tasks:

1. We will try to see what happens to white light when it goes through a prism
2. We will study spectra using telescope images and simulations.

We will set some research questions (Hypotheses) which we will investigate. Please write down your hypotheses to the following questions.

1. What happens to white light when it goes through a prism?
2. How are spectra created? How many types are there? Why and how are they different?

Students will be asked these questions so as to be both further engaged and checked about their background. An example concept map could be the following:

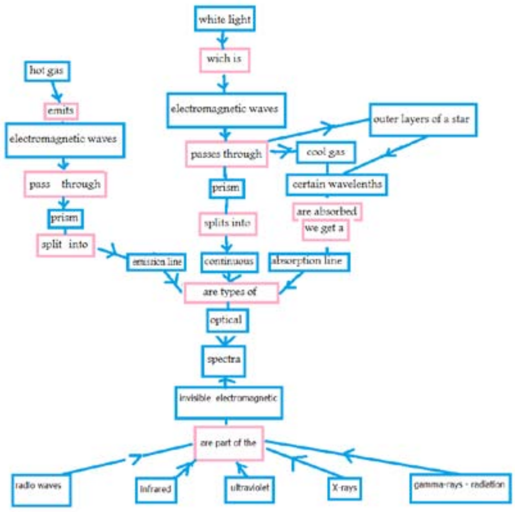

Figure 3. Concept map

Step3:

Students may be informed about what they will do during this exercise:

- Learn that a prism "disentangles" white light and separates all the colours out
- Study spectra of all kinds which they will collect themselves using at first their self-made spectroscope and finally a robotic telescope.

Tip: Do not point out any mistakes students might make. Students are supposed to discover these mistakes themselves and correct them. Alternatively, you may note them down and bring them back to their attention at a later stage.

Investigation

The investigation has two parts: “Spread the light out into a rainbow” and “Spectra”. Students are divided into groups of four. Two of each group will focus on spreading the light out and the other two on spectra. Once they have finished they will exchange information and results so as to be checked by each other.

Sub-phase: Experimentation

Analysis of white light – Electromagnetic spectrum

Step 1:

Visit the:

Figure 4. http://amazing-space.stsci.edu/resources/explorations/light/

Select *Catch the waves*. On top right corner there is theory (*Light facts*) about the phenomenon and brain teaser questions. You can move to the next Experiment by pressing the next button.

Firstly you watch how a prism “disentangles” white light and separates all the colours out.

Secondly you discover other kinds of electromagnetic radiation

Thirdly there are pictures of the Sun as seen in different Wavelengths. (so that students understand that there is a lot more than what we see…)

In the school lab perform the experiment: Analysis of white light as it is described in your school student’s book so as to assert the e-lab http://www.youtube.com/watch?v=5-H3p0TZDow

Note down your observations about white light analysis, electromagnetic spectrum and the light of our sun. Present your observations and briefly describe how you came up with them.

Step2:

Search the internet or open your school books so as to find out scientists’ observations and explanations of the phenomenon.

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- Are there any differences?
- What have you not mentioned?
- What have you misinterpreted?
- Do you have any objections?

Write a report out of the answers to the above questions.

Step3:

Now answer the brain teaser questions (e-lab) and the following ones

1. What does a prism do to white light? (a prism "disentangles" white light and separates all the colours out)
2. How is a rainbow formed? (Raindrops can act as a prism. Each raindrop breaks up and reflects the light from the sun).
3. Is the electromagnetic spectrum the same as the visible light spectrum (can we see all the parts of the electromagnetic spectrum)? (no The electromagnetic spectrum is divided into the visible part, which we are able to see, and the invisible which forms the greater part like radio waves, infrared, visible, ultraviolet, X-rays and gamma-rays – radiation emitted in nature).
4. Can the simple colours of the visible light spectrum be separated into other simpler colours? (no If we pass the colour blue through a prism it only changes direction without being separated out again.)
5. How do we separate all these different forms of radiation? (Each simple radiation is characterized by a very specific wavelength measurement.)

Spectra types

Step 1:

Firstly visit the:

Figure 5.
http://www.fr.euhou.net/docupload/files/SpectrJ/SpectrJ/eLesson/EN/Lesson01_intro.htm

Press the arrows so that you get to Types of optical Spectra 2.1. Continuous emission light and absorption light spectra

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Secondly visit the http://support.faulkes-telescope.com/SS433/Spectra_intro2.pdf and do the exercises (connection with prior knowledge) so that you realize how spectra lines are connected to atom energy levels.

Thirdly, if there is time, visit
http://amazing-space.stsci.edu/resources/explorations/light/stellarEncounters-frames.html
(so that you realise that spectra is the key to understanding the Universe).

Now use your spectroscope to observe spectra in the school lab and use the school spectroscope to perform the experiment http://www.youtube.com/watch?v=z8MSULFgI_w

Note down your observations about different types of spectra, similarities, differences, and origin. Present your observations and briefly describe how you came up with them.

Table 1: This table will help organize your observations

Material	Type of spectrum	Picture
Hydrogen		
Helium		
Carbon		
Oxygen		

Step 2:

Search the internet or open your school books so as to find out scientists' observations and explanations of spectra.

- Are there any differences?
- What have you not mentioned?
- What have you misinterpreted?
- Do you have any objections?

Write a report out of the answers to the above questions.

Step3:

Now answer the following questions:

1. Are all spectra the same? What does the form of electromagnetic spectrum emitted from a light source depend upon? (The form of electromagnetic spectrum which is emitted from a light source depends upon the type of the source and the conditions under which the emission takes place).
2. What do you know about the light emitted by celestial bodies? (All celestial bodies that give out light emit rays at a large part of the electromagnetic spectrum (visible and invisible) and according to their surface temperature they emit rays to mainly one area of the spectrum. However, all these electromagnetic waves do not reach us. The earth's atmosphere can be penetrated only by rays which are in the visible spectrum, in a

ISBN 978-615-5511-06-6

section of the infrared and the radio wave area.) Indeed spectra is the key to understanding the Universe.

ISBN 978-615-5511-06-6

Conclusion

Please try to answer the following questions in your notepad in order to reach a conclusion.

1. Are you pleased with the outcomes of your investigation?
2. Have your questions been properly answered?
3. Are there any data you couldn't categorise?
4. Would you make any suggestions to further improve the simulation?

Compare your original hypotheses to your conclusions. What did you think then? What do you think now? What made you change your mind? If the students had made any mistakes in the previous stages, make sure you bring them back to their attention so as to correct them.

Discussion

Sub-phase: Communication

Make a brief report of your work and present it to your class-mates. Be as creative as possible so as to attract their attention. (small videos, prezis, Power Point presentations, posters like those presented by scientists during conferences.… are more than welcome)

Sub-phase: Reflection

Compare your results and the parameters your team used to reach a conclusion with those of other teams. Are they similar? If not what are the differences? Have you done something wrong? How could you improve your methodology if you were to repeat the experiment? Propose corrective moves and refinements of the experimentation process. Be sure to point out their strong parts too!

ISBN 978-615-5511-06-6

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This lesson plan got the third position in Greece at the Go- Lab Contest in 2014.

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

TEACHER TRAINING USING SERIOUS GAMES: THE SIMAULA PROJECT

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Introduction

During recent decades, technology has been the main driver of economic and social transformation and modernization. The rapid technological advancements affected at breathtaking speed all spheres of life and changed dramatically the nature of the labour market that nowadays demands highly-skilled personnel with multi-dimensional capabilities. In a world where the problems have a global dimension and where the levels of unemployment and exclusion are rising, the future of young people is at stake. The changes in the labour market and the global financial and economic crisis posed new challenges to education that had to be modernized in order to be sustainable in the long run and ensure the next generations' chances for economic and social well-being. Education now more than ever has a fundamental role to play in the economic recovery and future prosperity. The contribution of education as the driving force of economic growth has emerged at the global forefront and investment in high-quality education has become a top priority in the European agenda.

In this context, the educational systems are in need of restructuring in order to ensure that all young people will be equipped with high levels of skills and competencies that are a necessity for active citizenship and a viable future in a constantly changing workplace. Nevertheless, no educational reform can be achieved without the co-operation and active participation of teachers. The teacher still remains the key wheel of education and with a vital role in the preparation of young people.

The challenges and boundaries of teacher training

The implementation of information and communication technologies (ICT) brought new challenges to teachers that must renew and enrich their skills and knowledge in order to respond effectively to the requirements of their profession. Much is expected and demanded of teachers within today's' multicultural and digitalized classroom environment. Thus, there is a need for well-trained teachers and with a sense of personal responsibility and duty in the preparation of learners with a range of skills needed to succeed in a globalized knowledge-driven world without boarders (Delors et al., 1996). The European Commission (2011; 2012) within the 'Education and Training 2020' strategic framework stresses the importance of teachers' professional development maximizing the quality of teachers and of education. However, the Joint Report on Key Competences for a Changing World by the Council and the

Commission (Council of the European Union, 2010) puts emphasis on the lack of opportunities for teachers to improve their teaching and skills.

It is essential that teacher education programs prepare future teachers to be scientifically qualified, innovative, and inventive, with excellent knowledge of their subject, equipped with all the modern methods and techniques and constantly updated about the latest developments (Lambaki, 2014). Additionally, teachers must have a deep understanding of their domain and pedagogy and be able to manage the situations that will arise in the classroom. Nevertheless, research indicates that initial teacher education does not adequately prepare pre-service teachers and as a result when teacher graduates enter the profession the lack the knowledge for effective teaching affecting negatively students' learning and achievement (Chiero & Beare, 2010; Ferry et al., 2006; Kirby et al., 2006; Mavrou & Meletiou-Mavrotheris, 2013). Furthermore, despite the penetration of technology in the workplace some teachers show unwillingness to adapt and modify their teaching practices to best suit today's classrooms (Lameras et al., 2014).

The most important element in teacher preparation programs is whether they provide or not real life school experiences to candidate teachers (Chiero & Beare, 2010). Nevertheless, teacher training within the university is theoretical, having a weak or no connection with classroom practice (Darling-Hammond et al., 2005; Hagger & McIntyre, 2006; Katsarou & Dedouli, 2008). Moreover, there is no cooperation between schools and universities deriving pre-service teachers from important feedback and mentoring from experienced teachers (Kirby et al., 2006; OECD, 2005). Without doubt an essential step in teacher training is the practical experience of teachers that will allow them to understand the challenges of the profession and implement what is being learned during their studies maximizing their expertize. Equal significant is the fact that no initial teacher education can equip teachers with all the knowledge and skills that they will need throughout their whole career (European Commission, 2013). Demands of the teaching profession are evolving rapidly and teacher quality can be achieved through life-long learning.

Improving teacher education via serious games: the SimAULA prototype

The last few years many efforts have been made to enrich teacher education programs with computer-based approaches in order to better prepare candidate teachers deal with the complexities of the classroom. One innovative tool that seems promising for the preparation of pre-service teachers is serious games. The last few years, serious games have whipped up the interest of the scientific community and their use as a training tool has grown tremendously in education however, research on the use of serious games in teacher training is still at its infancy (Van Staalduinen & De Freitas, 2011; Westera et al., 2008).

Serious games are 'computer games that have an educational and learning aspect and are not used just for entertainment purposes' (De Freitas & Liarokapis, 2011, p.10). They are designed with specific curriculum objectives and have clear educational objectives and feedback during the learning progress while they motivate the players through the challenges of the game

ISBN 978-615-5511-06-6

(Squire, 2005). The importance of serious games lies is their ability to connect players to everyday life situations allowing them to implement in real world situations the skills practiced in the game (Kebritchi & Hirumi, 2008). Users learn by doing, they are responsible for their actions and they learn from their mistakes (Anolli et al., 2010). Serious games can address the need for practice in teacher education and can provide teachers the feedback and mentoring that they need. Moreover, another significant advantage is that their use addresses the issue of safety in a real world setting, since they allow teachers room for error but without the risk of harming real life students (Foley & McAllister, 2005). Thus, serious games can provide teachers a realistic learning experience where they can test their abilities in real-life problems and enhance their knowledge and skills at low cost and in a safe manner. Furthermore, serious games allow teachers reflection and evaluation of their teaching promoting their professional development (Foley & McAllister, 2005).

One serious game that offers teachers innovative learning experiences is SimAULA. The SimAULA project supporting the 'Education and Training 2020' strategic framework about the professional development of the teaching staff adopted by the European Union aims at contributing to the improvement of the quality of training of the teaching staff through the introduction of innovative and interactive methods and strategies of learning. SimAULA was developed within the European project: SimAula Tomorrow's Teachers Training, Lifelong Learning: Comenius, ICT and Languages (http://www.simaulaproject.eu/).

The SimAULA three-dimensional virtual classroom aims to address the lack of school practicum experiences and provide a high quality of teacher education that will strengthen the weak connection between theory and practice in teachers' training. The main objective of SimAULA is to provide a training tool that through a system of training activities will empower teacher's professional development. SimAULA takes advantage of serious games technology and it is based on the constructivist theory of teaching and learning according to which the users-teachers of the game will 'learn by doing' and will discover knowledge through inquiry and experimentation (De Freitas, 2006; Oliveira et al., 2011).

SimAULA is a simulation of a Biology classroom in the context of a primary school and the topic to be taught is the 'biological cell' for 5th grade students (11-12 years old). The teacher has the control of an avatar (see Figure 1 below) and can interact with a group of students that are controlled by the computer (see Figure 2 below), develop lesson plans and teach within the virtual classroom. During the game teachers can experience three different pedagogical strategies -problem-based learning, learning through experiment and collaborative learning- (see figure quite a bit below) and they have to choose the learning activities and resources for their classroom. Resources can be either technology (i.e. computers, digital or traditional blackboards, etc.) or non-technological information sources (i.e. books, etc.). The choice of the learning activities and their duration must not be accidental but in accordance with the selected pedagogical strategy and resources; thus, it is important that teachers reflect on their choices as they will affect the success of the game.

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Figure 1. The avatar of the teacher and the avatars of the students

Figure 2. The different pedagogical strategies (problem-based learning, learning through experiment and collaborative learning)

The objective of the game is to achieve student's engagement by making the appropriate decisions during the game. Within the game teachers will have the ability to experience real classroom situations as students' non-participation or interruption of the course due to bad behaviour of a student and will have to take the appropriate course of action in order to ensure classroom harmony. Through repeated cycles of decision-making, experimentation, and refinement, the player builds expertise by developing new strategies and thinking like a teacher. Once the game is completed, SimAULA automatically generates an evaluation that provides feedback to the players about their performance.

SimAULA has been tested from September to December 2012, in three different educational settings: Italy, Bulgaria and Greece. Each partner country organized pilot tests for the evaluation of the platform by student-teachers and active teachers. Three questionnaires were used for the data collection. Participants had to complete the first questionnaire (that had to do with personal data), test the application and complete the second questionnaire that aimed to evaluate technology and usability aspects of SimAULA. Then, participants had to play SimAULA for a second time and complete the third questionnaire that aimed to evaluate the pedagogical aspects of SimAULA.

The results of the research revealed that SimAULA is an innovative tool that provides a safe virtual classroom environment where teachers can experience situations that they will meet in real-life, they can act and reflect on their practice. The participants detected several technical problems in the application as SimAULA was still under development and dysfunctional. However, despite the technical problems experienced including servers, computers and connection and access to the game, SimAULA was identified as a game easy in use and without time consuming requirements.

The main weakness of SimAULA was the graphic design of the game that did not make the classroom environment very realistic. As a result the participants could not be emotionally involved, as the low levels of interactions did not engage them and did not make them feel a sense of present meaning that they did not feel like being close to teachers' reality. Moreover, many of the participants did not find the situations and the scenarios of the game close to those of a real classroom setting. Furthermore, the results revealed that the final evaluation report given by SimAULA was poor and did not promote metacognition. Nevertheless, participants showed a great interest in the idea of a classroom simulation that will complement their training. Another significant result of the research is that participants found SimAULA beneficial for their practice and they would play it again. Moreover, almost all participants want SimAULA to be expanded on other curriculum apart from biology.

The overall experience with SimAULA was positive and the participants identified the potential of using serious games in the preparation of teachers for physical practicum. SimAULA can be a powerful tool offering high theoretical and practical training to teachers in a pleasant, friendly and safe virtual environment. With relatively short time teachers can experiment in different teaching techniques and learning situations and strategies.

SimAULA: promoting inquiry-based learning

The pilot tests of the initial SimAULA version demonstrated the possibility to train teachers through the use of serious games. The most significant aspect of using SimAULA is that it provides pre-service teachers with 'lived experiences' (Lameras et al., 2004, p. 87) that 'are transferrable to the real classroom' setting (Lameras et al., 2014, p.86). The first version of the game has been updated and the new version not only promotes classroom and behaviour management but it promotes inquiry-based teaching enhancing teachers' skills in the design of inquiry-based lesson plans (Lameras et al., 2014).

Inquiry-based learning 'encourages students to actively construct their own knowledge…bring their personal ideas into the discussion, identify concepts important to the learning experience, make changes in their attitudes and behaviours…compare their own assumptions, use critical and logical thinking, and consider alternative explanations' (Lucas & Jarrett, 2015, p.64). For SimAULA inquiry is defined 'as an active learning process engaged in by students and modelled on the inquiry practices of professional scientists' (Lameras et al., 2014, p.88). The inquiry model that constitutes the heart of SimAULA is described according to Lameras et al. (2014, p.89) as 'a cyclical path of the inquiry process where inquiry starts with asking questions and ends with reflection. Each step in the process leads to the next, generating new questions, constituting evidence, analyzing evidence, formulating explanations, connecting explanations, communicating findings and reflecting on the process' (see Figure 3).

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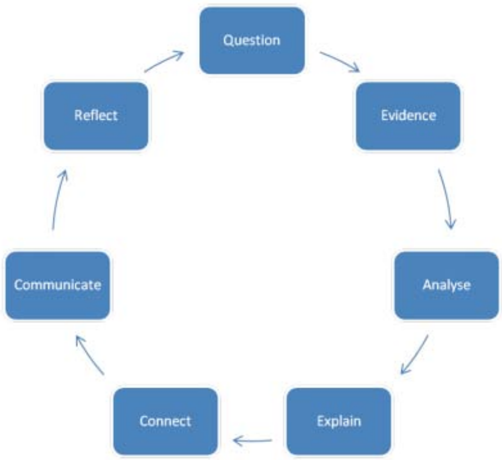

Figure 3. The SimAULA 7-step Inquiry Model (from Lameras et al., 2014, p.89)

The architecture of the updated version of SimAULA is almost the same as in the initial one. The user-teacher has the role of the science teacher and must develop lesson plans during the game while interacting with the students that are controlled by the computer (see Figure 4 below). According to the users' choices the virtual students will react as they would do in the traditional classroom. The user-teachers will have to manage the classroom and the problematic behaviours of the students that might arise (see Figure 5 below).

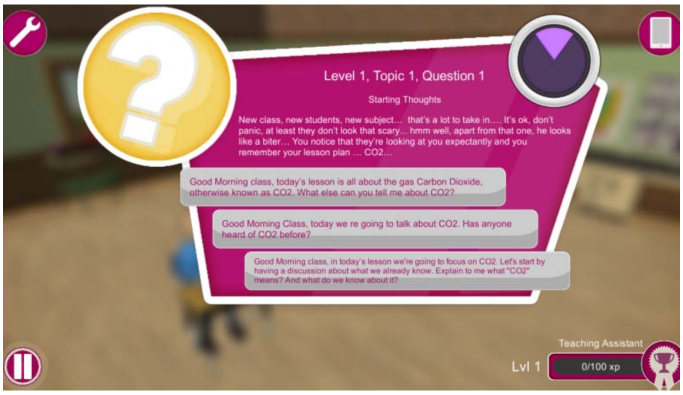

Figure 4. Developing the lesson plan during the game

Figure 5. The SimAULA classroom environment

During the game the user-teachers will have to select from an amount of options offered by the system and based on the selections the students will react allowing teachers to experience various different behaviours. What is important is that the main objective of SimAULA is to enhance teachers' science teaching skills through the evaluation and reflection of their inquiry choices during the game. Reflection is an important process and an integral component of SimAULA that will allow teachers to understand their choices, develop deep knowledge and enhance their teaching skills from their experience.

Final thoughts

This paper presented the SimAULA serious game that aims to train pre-service and in-service teachers and empower them with the necessary skills and competencies for successful classroom and behaviour management. Research on the initial SimAULA prototype revealed the potential of using serious games in the preparation of future teachers. The research formed the basis for modifications in the initial prototype of SimAULA and a new version has been updated and will be evaluated during the next few months. The latest version of SimAULA has been enriched with inquiry-based learning activities and student problematic behaviours providing teachers with significant practical experience. Through reflective practice teachers will have the ability to look back and evaluate past actions learning from their own personal experience. In the future SimAULA aims to promote the use of serious games technology within the university curriculum complementing the traditional teacher training methods. Furthermore, as the demands of the teaching profession are evolving rapidly and no initial education can sufficiently prepare teachers, SimAULA aims to serve as an innovative life-long learning tool for the continuous professional development of teachers throughout their career.

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

SCHOOL ON THE CLOUD: TRANSFORMING OPEN CLASSROOM

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Introduction

In epistemology, in the last few years, important differentiations have occurred related to the way we view education as well as its applications. These changes in perception are of particular importance, because they clearly show the need for a new approach to Education. More specifically, we need to clarify the fundamental principles that determine nowadays the way education is regarded and the methods used in teaching and learning.

At the onset, this paper unambiguously declares that nowadays at the centre of the pedagogic approach towards teaching and learning should be the concept of *integration*. This leads to the position that not only the traditional *Teacher Centred Instructing* educational paradigm, as well as the much herald present approaches to education, defined as the *Student Centred Learning* paradigm, are now absolute and we find ourselves in the period of the *Net Centred Knowing* paradigm which is based on Cloud Computing.

More specifically, the position presented here is simple in its explanation, but radical when is considered in terms of the excising beliefs and practices in the education community. That is, today's major educational stakeholders require combined and simultaneous capabilities that cannot be dealt with unless we accept the fact that they represent different manifestations of "a whole", the dialectic entity of education. Therefore, an integrated approach towards teaching and learning is required, an approach that is not possible without the help of the *educational abilities provided by Cloud Computing*. But understanding such an approach to teaching and learning is possible only through an examination of their nature and their evolution, which in turn determines how we perceive education as well as how we practice it. However, these two dimensions have recently been involved in changes representing what epistemologist Thomas Khun (1962) has termed paradigm shifts and which are presented below.

Considering Education

The way we view education has altered in the last century following changes in the way we reconstruct societal values and consider important societal goals. That is, in order to successfully prepare students for the future we cannot continue educating them in ways that address education and market needs of the past (Fullan & Langworthy, 2013). As a result, although the world has been changing in ways that are not always easy to understand, at the same time it is imperative to be able to accurately respond and prepare our students for these changes and needs. In other words, every time a change is happening a new educational approach is needed to educate students for the challenging future (Gialamas et al., 2013). Following is a brief presentation of these changes and the resultant responses which were determined by the way we considered education every time.

Monodisciplinary approach

From the beginning of the 20th century and for some years following World War II, education had a value that society systematically downgraded and considered it as just a tool in attaining other pressing societal objectives. This was accompanied by the inefficient way disciplines were operating. More specifically, every particular scientific endeavour was concerned only with its own subject area. As a result, concern for education was treated, like the rest of the disciplines, in a *monodisciplinary* manner. In other words, the teaching and learning aspects of education represented the exclusive realm of educators who were the only ones that could offer the methods, techniques and knowledge to handle education, for the simple reason that society and other scientist had little or no interest in them. In this monodisciplinary approach, however, the practitioners of every discipline through their "exclusive" paradigm have been creating a *"fragmented"* approach to societal needs and obligations, including education, which was providing a fragmented and mainly a descriptive learning process (the way students need to learn). Therefore, it is of no surprise that educators followed the well-known and long lasting traditional *Teacher Centred Instructing* paradigm, whose main teaching tool has been teachers' instruction (Figure 1, left first row).

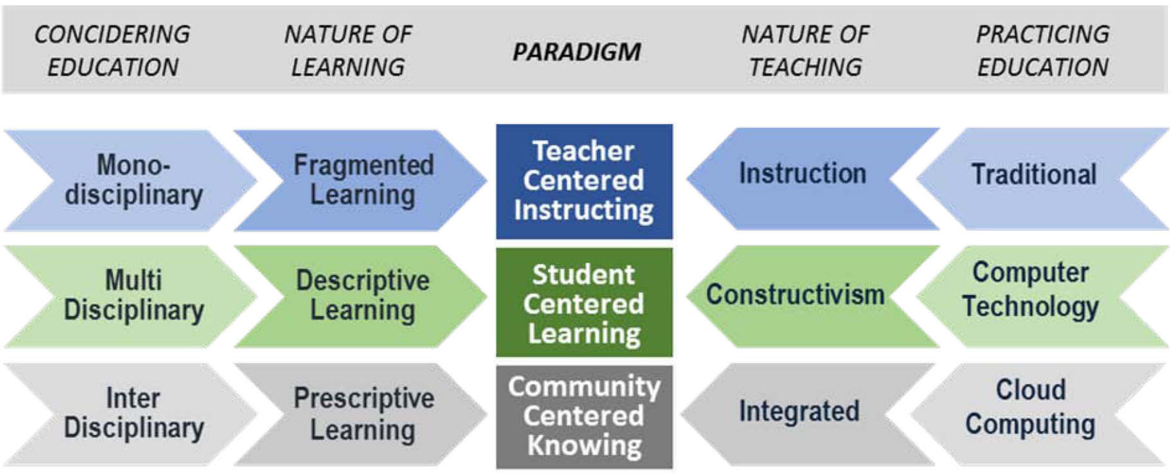

Figure 1. Paradigm Changes in Education

Multidisciplinary Approach

In the 1970's the significance of education was recognized and the requirements of teaching and learning acquired a place at the centre of societal interests. In addition, however, there was the strong questioning of the monodisciplinary practices by the scientific community, which resulted in the development of an alternative consideration. More specifically, all societal needs and practices were required to be approached from various perspectives and concerns, which led to a *multidisciplinary* approach towards education. Under this perspective, education was treated by the society and other interested scientists as if it consisted of the sum of all the distinct parts of a multidimensional cultural, political, social,

Transforming Schools into Innovative Learning Organisations
EDEN Open Classroom Conference Proceedings, 2015, Athens
ISBN 978-615-5511-06-6

environmental and economic reality. In other words, because human knowledge necessitates "abstractions" of all aspects of reality, learning was expressed in the form of a set of *separate* relations, interdependences and interactions, providing still a descriptive learning education. But this notion of a descriptive -multidimensional education required a constructivism approach in the classroom, which in turn formed the basis of the education paradigm presently in use and defined as *Student Centred Learning*. A paradigm that is focusing, in a descriptive way, on both individual learners (their heredity, perspectives, backgrounds, talents, interests, capacities, and needs) and on learning itself (the best available practices that promote the highest levels of motivation, learning, and achievement for all learners and which is still the main mode of operation for open classroom efforts (Figure 1, left second row).

Interdisciplinary Approach

The premise of this paper is that today this multidisciplinary approach cannot be accepted anymore. It is suggested that an integrated approach is necessary, which has to be simultaneously cultural (i.e. new role of students), pedagogical (i.e. new role of teachers), technical/technological (i.e. use of the internet), administrative (i.e. new role of school administrators), social (i.e. a different disposition of parents towards school) and political (i.e. a different approach of government to school), in dialectic harmony and respecting all aspects of teaching and learning an integral part of which are the basic education stakeholders (pupils, teachers and school administrators).

In other words, it is argued that a holistic learning approach is required in order to express the multidimensional relationships and interdependencies of all the stakeholders that constitute the specific entities participating in the education process, which is the "whole". As a result, an *interdisciplinary* approach is required, which leads towards the integration of all possible learning actors and approaches in order to overcome the compartmentalization of knowledge. However, such a regard of learning establishes a holistic education which provides *prescriptive* learning (the way students should learn) and leads towards a new paradigm in education, named in this paper *Net Centred Knowing*. That is, we suggest that the "participatory" approach of the student centred education, which emphasizes the active involvement of students in the learning process, now is being substituted by a holistic approach towards knowledge, which is the foundation of the new Net Centred Knowing paradigm (Figure 1, left third row) and which we propose that open classroom approaches have to shift towards it.

Practicing Education

Teaching methods as well as educational curricula have been changing, but the key to understanding these changes is the appreciation of the swift changes of how we regard education, which has changed from an old paradigm filled with traditional instruction methods to another anchored in computer technology and finally to a new one where cloud computing with its integration capabilities plays the central or the determining role. Therefore, it is suggested that practicing education has, in the span of a little more than half a century, undergone the following transformations (Figure 1, right rows).

ISBN 978-615-5511-06-6

Traditional or Instruction Approach

The traditional approach, which lasted until a few years ago, was very simple: the teacher transmits information to students who passively listen and acquire facts. Pedagogically, in this approach subject matter and teaching methods are focusing on the simple transmission or instruction based curriculum leading to a Teacher Centred Instructing teaching process. As a result, as Fowler and Mayes (2000) pointed out, there is a "representational" view of learning with its concomitant "transmission of knowledge" by instruction approach, which determines the design and operation of the learning environment. All these characteristics and practices lead towards the well-known and long lasting traditional Teacher Centred Instructing paradigm (Figure 1, Right first row).

Computer Technology or Constructivism Approach

The increased use of microprocessors altered the traditional teaching approach creating a new one based on *computer technology*. It was accepted by educators and policy makers alike that education had to be in the information business (or no business at all) and most of the pedagogical tasks in the classroom or outside it had to be accomplished by utilizing some form of computer technology. This resulted in the emergence of a new information education in the context of a world of computers and interactive software. The use of computer technologies, however, emphasizes the importance of creating engaging learning environments that provide students with meaningful learning experiences from various forms of learning relationships which are the result of interactions between learners and content, learners and learners and learners and teachers (Godwin and Kaplan, 2008). In other words this corresponds to a Student-Centred Learning education which involves both learning and the learner.

But such an approach to education basically re-envisions education by drawing on social constructivist educational philosophies (Cormier, 2008). An approach which emphasizes the importance of interrelationships between persons participating in the teaching and learning processes and the kinds of interactions that need to be fostered in planning learning resources to create participatory learning experiences. In other words, it is based on *Constructivism,* and not Constructionism, a theory which is based on observation and scientific study and determines how students learn and how they construct their own understanding and knowledge of the world, by experiencing things and reflecting on them. As a result, the constructivist view of learning leads towards teaching practices encouraging students to use participatory techniques such as experiments and real-world problem solving, in order to formulate learning and reflect on, as well as talk about what they are doing and how their learning is improving. Thus establishing the education paradigm presently in use, defined as Student Centred Learning (Figure 1, right second row) and which apparently forms the basis for open classrooms, which by definition are a student centred approach focusing on students "learning by doing".

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The Integrated or Cloud Computing Approach

Up to now the three basic educational stakeholders (students, teachers and administrators) were considered by the education community as independent and sometimes conflicting pedagogical forces (Kohl, 1969; Koutsopoulos, 2008). However, the thesis of this paper is that such an approach is clearly scientifically shallow, logically unsound and mainly lacking the necessary integration required in the complicated and dialectic present day scientific, societal and educational environment. That is, although the adoption of new computer technology techniques in teaching is imperative, nevertheless technology cannot be utilized alone, ignoring the other educational actors (i.e. teachers with no computer skills or lack of understanding from decision makers

Basically, all stakeholders in the pedagogical process are teaching and learning factors, which have as common background their educational dimension. But most importantly, they are closely interrelated and not independent, inadvertently complementary and not conflicting and thus they can be integrated into an educational "whole". As a result, according to this paper, they should be considered as components of an integrated teaching approach representing different manifestations of a holistic teaching methodology. That is, the nature of teaching is a lot more and well beyond a constructivist approach, because the new way of practicing education encompasses beyond ICT tools, all stakeholders in different ways so that it transforms their role, approach and services.

This is particular true in terms of the open classroom concept which is characterised as containing no whole-class lessons, no standardized tests, and no detailed curriculum. Moreover it plans settings where children came in contact with information and education sources (unfortunately up to now only with non-digital "play tools" and books), as well as one another at "interest centres" and learn at their own pace with the help of the teacher, following a pure constructivist approach. Therefore, open classroom is in desperate need for a new paradigm. Indeed, in the last few years discussions about "Open classroom" range between meaningless intellectual chatter and ideas that provoke substantive change. We believe the later, but we propose a different approach to avoid the former.

Cloud computing can fulfil the needs required by the new paradigm, because it represents a fundamental change in the way computing power is generated and distributed. Indeed, as Microsoft (2012) has declared "With Cloud computing in education, you get powerful software and massive computing resources where and when you need them (and we may add in any way you desire), in order to apply new educational approaches .Cloud services can be used to combine on-demand computing and storage, familiar experience with on-demand scalability and online services for anywhere, anytime access to powerful web-based tools". That is, it represents a framework which can successfully serve and support an integrated approach to education and which is basically what open classroom desperately requires to move towards it. Moreover, although cloud computing approaches are similar to the computer technology ones in addressing teaching issues they differ in one significant aspect. Namely, they represent the pieces of a holistic and integrating framework by providing an

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information system domain within which virtually all aspects of education can be practiced. This dialectic concept, by emphasizing a holistic view of education, is broader than data or information; it is open rather than closed; it can accommodate pluralistic teaching styles; and offers no restrictions on subject matter, curriculum or classroom setting. And thus provide the foundation of the new Net Centred Knowing paradigm (Figure 1, right third row) and in particular addresses open classroom teaching and learning requirements.

School on the Cloud

From the previous discussion it should be clear that there is a need to thoroughly examine and evaluate the interface between education and cloud computing as well as explore how teaching and learning should respond to new ICT developments, in the form of cloud computing, that are transforming education and will continue to do so in the immediate future. That need and the ideas behind it were shared by many ICT experts and educators, who formed the School on the Cloud network which seeks to achieve its goal and objectives by addressing the following two key questions: How should education respond to cloud-based technologies? What is the impact, now and in the future, on education stakeholders?

Answering these questions in essence creates the foundations in applying the new Net Centred Knowing education paradigm. In addition, however, it provides the vehicle for accommodating the difficulties, trials and tribulations of the classical book "Open Classroom" by H.R Kohl (1969) and re-establishes its value as well as guarantee the triumph of his ideas. The reason is simple: as learning becomes increasingly digital, cloud-based developments become the necessary vehicle for a new integrated way to education (Donert & Bonanou, 2014). An approach that aligns with the way we think, share, learn and collaborate, inside and outside the classroom, in an open or closed classroom , which in turn allows education to be holistic as well as bring into teaching and learning the necessary dynamic, interactive and multimedia tools.

What Cloud Computing Brings to Education

Experience and the literature (IBM, 2013; Gaytos, 2012; Duggan, 2012) shows that there is a range of resources and services available to education using cloud computing. The most commonly referred and important as well as useful to open classroom (for a detailed description see Koutsopoulos, 2015) are:

- **Savings**: in money, recourses and efforts;
- **Flexibility**: in time, space, equipment, programs etc.;
- **Effectiveness**: in information, tools effective learning and teaching process;
- **Sharing**: skills, good practices, applications, teaching content and infrastructures;
- **Real time Access**: of useful and free information from anywhere;
- **Reducing the Risk of Obsolescence**: providing insurance against technological changes.

ISBN 978-615-5511-06-6

What Cloud Computing Brings Directly to Open Classroom

Advances in ICT, in the form of cloud computing, continue unabated and there is an increasingly perceived vision that cloud based education should be the single most important path towards a successful education. In other words, it is suggested that the use of cloud computing in the classroom has an impact on the fundamental elements of classroom education (the subjects taught and the teaching and learning methods in attaining them), as well in the changing role of several influential factors (for details see Koutsopoulos, 2015), such as:

- **Subjects**: In terms of the teaching subjects it is suggested that computing is the 4th fundamental subject that students should master (in addition to reading, writing and arithmetic).
- **Learning**: Several studies (i.e. European Commission/ Horizon Report Europe: 2014) support the thesis of this paper that recent developments related to dexterities, skills and competences, require changes in our schools such as those advocated by open classroom advocates. (Among others, Learning should be focused on: the Needs of Individuals; a Holistic New Vision; Open, Flexible and Networked Relationships as well as be active and Connected to Real Life).
- **Teaching**: In the learning and the digital landscape in which education is presently operating, requires comparable teaching methods (i.e. Collaborative, Collective, Personalized teaching).
- **The Changing Role of Education Factors**: Cloud Computing with the recourses it provides to educational factors (Students, *Teachers*, *School Administrators, Transforming of Knowledge, Social Media, Open Education Resources etc.),* it forces them to adapt to developing situations, which in turn change their place and role in the education process in accordance with the basic principles of open classroom.

Conclusions

Present day students all of which have practically been born in the 21st century, representing the so called Z Generation, are growing and operating in an environment where collaboration and exchanges are spontaneous, learning has become ad hoc and networks are imperative, forming an intrinsic part of their lives. Moreover, surfing the Net, looking for new encounters and experiences has become virtually their “first nature”. As a result, using yesterday’s teaching tools do not correspond to their needs and their very nature. In 1964 Marshall McLuhan, introduced the phrase “the medium is the message”, suggesting that the means in most cases is the end. This dictum is certainly appropriate in education, where there is a tight relationship between technology and learning. That is, as technology has become an agent of immense change, it has forced upon the education system cloud computing and has given rise to changes that have a significant ripple effect on education practices including open classroom .

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In conclusion, the efforts undertaken by the School on the Cloud up to now to address the changes in school education as a result of cloud computing, shows that this technology is shaping, changing and enabling new ways of accessing, understanding and creating knowledge, and will continue to be part of all education stakeholders' lives, because it can face the requirements posed by present day and future education and market needs. Moreover, all education stakeholders need tools such as those offered by cloud computing that are more versatile and can adapt to new developments. In other words, the proposition of this paper is that *ICT in the form of Cloud Computing already is and will continue to be an integral part of teaching and learning as well as managing schools, and this holds more for the survival of open classroom practices.*

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

PEER SCAFFOLDING DURING VIRTUAL TINKERING IN A CONSTRUCTIONISM LEARNING ENVIRONMENT

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Abstract

Constructionism Learning Theory places emphasis on the individual's personal connection to the subject of learning, as a way of internalizing the structures that lead to the acquisition of knowledge. If the individual has the opportunity to tinker with material in order to test, control and correct his/her construct, as well as the opportunity to interact with peers in order to support each other during problem solving, then the best possible result can occur. The role of new technologies, especially those that allow the creation of interactive constructs, is to enable people with respect to the above. The purpose of this research is to empirically investigate the features of the process of social scaffolding, in a tinkerable virtual environment. Three groups, each consisting of three students of the age of 11 had the opportunity to engage in such activity, while working on Scratch programming environment. Qualitative analysis of the data gathered through case study shows that social scaffolding in a virtual tinkering environment takes place in a context of active engagement and continuous dialogue. In such a context participants apply directly to others in order to seek support, mainly through questions and they take immediate response from others, mainly in the form of suggestion. Taking advantage of the support offered, the result is a continuous reshape of the construct to the final desired result. This study offers a general description of the way that social scaffolding takes place in an environment of virtual tinkering and it could consist the base for future study of this phenomenon.

Key words: Constructionism Learning Theory, Tinkering, Scratch, Social scaffolding.

Introduction

Papert and his theory of learning (*Constructionism Learning Theory*), has greatly influenced the way educators and researchers approach the reform of education and how new technologies play their role in constructive learning (Kafai & Resnick, 1996), as new technologies facility the construction and the sharing of constructs in the physical and virtual world (Resnick & Rosenbaum, 2013). There are various approaches of developing such activities with some leading to richer learning experiences, especially if accompanied by test-control-correction opportunities during the activity of construction (Resnick & Rosenbaum, 2013). This process shall be delivered by the term of *tinkering*.

Tinkering describes the way a person makes small changes to something in an attempt to repair it or to improve it ("Tinkering", 2015). Such an environment where students can become media producers creating interactive stories, games, animations and many more, while tinkering with the material and at the same time interacting with other people is the Scratch programming environment (http://scratch.mit.edu).

Interaction with others during such an activity has added value and should be promoted. Lu and Churchill (2012) argue that the social dimension to learning based on constructivist learning theories, is linked to participation in social interactions as well as to socio-emotional factors resulting in a learning community.

Constructionism Learning Theory

Constructionism Learning Theory is based on the belief that learning occurs as the person gives substance to his ideas by constructing them (Papert & Harel, 1991). It focuses on *learning how to learn* and in the importance of the process during the construction of learning, rather than on the overall cognitive potential of the individual (Ackermann, 2001). According to this theory, the learning process becomes more effective when carried out in a context where the learner gets consciously involved, by constructing something (Papert & Harel, 1991). Constructionism suggests that the best way to ensure that such intellectual structures form in the mind of the learner, is through the active construction of something tangible and shareable (Stager, 2002; 2005).

Tinkering

According to Wilkinson and Petrich (2014), tinkering is "fooling around" directly with phenomena, tools, and materials, "thinking with your hands" and learning by doing. Papert considers tinkering as an emergent activity, where a lot of back and forth goes on during the construction of the object, with deconstruction and reconstruction of the object playing an important role, until the thought of the learner can be externalized (Alimisis & Kynigos, 2009).

Whereas planners typically rely on formal rules and abstract calculations, tinkerers tend to react to the specific details of a particular situation. Instead of the top-down approach of traditional planning, what happens with tinkerers is the use of a bottom-up approach where they start with a general goal or a tentative plan and they continually adapt and renegotiate their plans based on their interactions with the materials and people they are working with (Resnick & Rosenbaum, 2013). Another important feature of tinkering is the way errors are managed. In planned activities errors are considered as steps in the wrong direction, while tinkering leads naturally to correcting them (Turkle, 2011).

According to the Exploratorium Tinkering Studio (http://tinkering.exploratorium.edu), one of the four learning dimensions of Tinkering is *Social Scaffolding.* It is a feature that takes place between people in a group, while request or offer help, inspire others with new ideas and approaches and physically connect to others' work.

Social Scaffolding

Scaffolding occurs when the learner receives assistance in order to perform a task which would be beyond his/her capabilities to execute by him/herself (Wood, Bruner & Ross, 1976). It derives from Vygotsky's ZPD theory which determines the distance between what a person can accomplish by him/herself and those under the guidance of an adult or through collaboration with more capable peers (Vygotsky, 1978). The construction of concepts is not considered an expression of individual mental representations but joint achievements resulting from the interaction of the participants, where cooperation promotes the process of shared concepts (Stahl, Koschmann & Suthers, 2006).

According to Howe (2013), scaffolding should not exist for the sake of accomplishing a certain goal. Tinkering also opposites to the accomplishment of a goal, but it rather focuses on the procedure and what that includes in an attempt to achieve that goal. According to van de Pol, Volman and Beishuizen (2010), scaffolding varies depending on the occasion, and it does not consist of a technique that can be implemented in the same way under all circumstances. According to the existing literature, given data only refer to physical tinkering. We have no evidence about virtual tinkering, nor evidence about the social aspect of tinkering. What we are interested in, is the way that scaffolding is formed in a virtual tinkering context.

Scratch

Scratch is an open source programming environment which allows the production of a wide range of interactive creations such as video games, simulations, greeting cards, virtual tours and many more (Resnick, et al., 2009). It was firstly created to reinforce technological literacy of children coming from disadvantaged families, during their afterschool hours (Vossoughi et al., 2013). As the users plan and share their creations they learn to think creatively, to give reasonable explanations and to work collaboratively – basic skills of the 21st century. Scratch is based on constructionism and it recognizes in the process of learning the need for an external construction, which supports the conceptual construction (Meerbaum-Salant, Armoni & Ben-Ari, 2013).

Trial and error as a basic principle of tinkering in Scratch, encourages and supports the bottom-up development of a scenario where building materials are combined, tested and assembled in larger building materials (Maloney et al., 2010). Scratch is considered to be tinkerable since users can leave "building materials" scattered on the desktop, in order to experiment later with them, sending the message that there is no problem if there is a "mess" (Resnick, et al., 2009).

Although Scratch is characterized as tinkerable (Resnick, 2007; Resnick, et al., 2009; Resnick & Rosenbaum, 2013), not empirical studies have yet investigated this aspect. Key to creating this environment is to support self-directed learning through tinkering and collaboration among peers (Maloney et al., 2010). However there is no research data describing the way social interaction takes place in Scratch's environment.

Transforming Schools into Innovative Learning Organisations
EDEN Open Classroom Conference Proceedings, 2015, Athens
ISBN 978-615-5511-06-6

Research Questions

This research aims to study the way social interaction among peers is expressed during their involvement in a virtual tinkering environment and to give evidence that describe the way they perform social scaffolding, in an effort to build up their own digital story. As a conclusion from the literature review, a common vital element between constructionism learning theory, tinkering and Scratch, is social interaction. The research questions arising from the above, are:

1. What is the nature of social scaffolding between peers during virtual tinkering? How it is formed amongst the peers involved in the group, under what conditions and what are the elements that characterize it?
2. With what procedures do social scaffolding is achieved during virtual tinkering? How the members of the group seek for help from others in an effort to find a solution and how others respond to that search?
3. How does social scaffolding form the final result of the construct? Does it favour the revision of ideas leading to the reform of the final result?

Methods

A case study was conducted through observation which focused on the interaction of three peer members in three different groups. Particular emphasis was given on how the team members asked for or gave support during an activity of creating a virtual story. The sample – 9 students of the age of eleven – was divided into three mixed groups. For the collection of the data, three separate meetings with the researcher with each one of the groups took place. Meetings were held during students' afternoon full-day attendance and off the official school's programme. The reason is because there is a growing recognition that afternoon centres and clubs as well as other informal learning environments can play an important role in the integration of technology (Maloney, Peppler, Kafai, Resnick & Rusk, 2008).

One of the benefits of informal learning environments is that children can undisturbed explore their interests, without the time limit set by the official curriculum (Peppler & Kafai, 2007). As a person being in the process of tinkering does not follow step by step instructions that will lead to a particular result, it is necessary to have time to reflect upon the outcome, speculate and review by its own terms (Wilkinson & Petrich, 2014). This implies a time-consuming process for the people to repeat this cycle (as many times needed) in order to gain as many experiences as possible (Resnick, 2007).

The groups were asked to build their own product in the Scratch programming software, using the principles of tinkering. That means that they followed a bottom-up approach, without the use of any step by step instructions, but they were able to "play" with the available material, deciding themselves what is useful and what is not, how to implement it etc. Each group worked for three continuous teaching periods on a common computer to make their own product on Scratch. The basic idea was common for all the groups while the decisions for its implementation were taken by the members of the group.

The aim of the activity was to create a program to include the use of motion and speech commands, control commands such as rotation, repeat and wait, adjusting the speed of the program execution and storage. Peers were asked to implement the above in any way they wanted, so as to bring the desired effect. During the activity they were given the opportunity to apply their previous knowledge to solve a problem using Scratch, as well as the opportunity to seek for help from each other and offer their own assistance when needed. While tinkering gives emphasis on the process rather than on the knowledge or on the final product, the aim of the activity was to encourage interaction among peers, regardless the result. Moreover, the completion of the project was not a priority for this task, rather was the collection of data related to the interaction of people in the group during the activity.

Data collection aimed to identify patterns between the three groups, specifically the extent in which same or similar characteristics occur between the groups in relation to the interaction between individuals that compose it. Emphasis was given on dialogues between peers and to extraverbal elements such as gestures gazes and expressions. A video camera was used during the activity in order to capture the data needed.

Data analysis

At first videos were transcribed, then dialogues were written in the form of text and video recordings were investigated for detecting any extraverbal elements that indicate support. Then, open coding technique was used in order to highlight all of the concepts that may arise and which would give answers to the research questions. Those concepts were written as codes in the text. All possible codes were noted, without restrictions nor the use of a specific format from the literature. Codes were then listed and this was followed by grouping them into categories to identify and correlate their concepts.

Depending on their meaning, codes were grouped into five major categories:

1. Seeking for help: The way the members of the group rely to others in order to find a solution to a problem or look for a new idea.
2. Offer assistance: The way members correspond to others that need help.
3. Intervention: The way members of the group interfere to provide assistance, proposing a solution or new idea, without any request.
4. Utilization of the assistance offered: Whether the members of the group accept and use solutions or suggestions offered to them.
5. Extraverbal elements for seeking or offering assistance (The way in which search and helping expressed without the use of language but with gestures or expressions).

Results

Analysis shows that the factors which characterize social scaffolding in a virtual tinkering environment is direct seeking of support from one another, response of people in the need of others for support and appropriate evaluation of the support offered. This results through

ISBN 978-615-5511-06-6

active engagement and continuous dialogue. According to Ackermann (1996), the element of dialogue, articulation and thinking aloud is favoured by constructionism learning theory and it is an important aspect in the process of assimilation of the concept, where the person becomes external observer of its construction, a narrator (to himself or to others) on the result and an evaluator of his/her ideas and decisions. Through dialogue, individuals not only benefit from the assistance offered by others, but they also internalize the new information transmitted between members (Leone, 2012).

The way with which peers seek help from each other in their effort to find a solution to a problem is achieved in three main ways: i) Directly questioning (63 times), ii) Using a statement which shows the need for assistant (38 times), iii) Using a statement which shows that one of the members faces concerns about his/her decisions (46 times). The major element of the call for support as indicated by the results is the question. By requesting, peers appeal to others to get help, where according to Petrich, Wilkinson and Bevan (2013) the learners become natural facilitators when someone asks for help from someone who has already found the solution. According to the analysis this leads to direct response from others. The way in which members of the group respond to others' call for help, is mainly through suggestion about what they evaluate as the best action (40 times) and through direct reply to the question in the form of an answer (20 times). Suggestion flows naturally within Scratch, as one of its principles is open investigation, which encourages people to discuss any wrong choices, either through questions, or suggestions for alternatives (Resnick & Rosenbaum, 2013).

Sometimes support is provided even without being asked, mainly through suggestion as well. It is important that participants can assess whether others are less able peers or not, since according to Leone (2012) there should be a balance in providing support to avoid either its excessive presence where not required or lack of help when really needed. It is important to note that in this case, it was not something that was expected of the participants.

The use of the support provided is performed mostly by agreement to the suggestion and implementation of the idea given (89 times), or by disagreement and rejection (61 times). As shown by the results, both cases are valuable since even through disagreement there is an iterative cycle of review for the solution proposed. One of the key features of Scratch is flowing experimentation which along to instant feedback allows the result to be observed directly, the idea to be visualized without waste of time, so changes can be made while the program is running, the user experiments and revises its objectives, a process that leads the creation to perfection (Resnick & Rosenbaum, 2013).

Social scaffolding as shown by the results of this analysis shapes the final result with two diametrically opposite ways. Individuals take into account the suggestions of their peers and either they accept and apply them, either they disagree with them and reject them. If the second case occurs, a new cycle of dialogue begins, with new elements of support, until the person who seeks support accepts the best solution that serves him/her the best.

As for extraverbal communication, it seems that in this case study it does not play any particular role in the shaping of social scaffolding during virtual tinkering, nor shaping the outcome. This probably occurs because the activity takes place in a virtual tinkering context (which differs from other traditional contexts) having the attention of peers focusing mainly on the computer. The fact that there are some forms of extraverbal communication may due to the fact that some of the children (as the one of the three children of group A) did not have the confidence of other children. In this case communication is performed through facial expressions, gestures and gazes. However she participated actively and equitably with the other team members. According to Petrich, Wilkinson and Bevan (2013) observations from the Tinkering Studio, show that active participation can take place even tacitly.

Limitations / Suggestions

The results of this study are defined in relation to the very small size of the sample and the narrow extent of the survey, which do not allow generalization of the results. For this reason statistical analysis has not been used. This research represents an initial effort to explore the nature of social scaffolding in a virtual tinkering environment and to find data to describe it. Since there is a lack of empirical studies that focus on the practical aspect of tinkering, giving an overview of this phenomenon is considered to be very important. This survey has produced considerable data which could be used for future exploration of the phenomenon of social scaffolding in a virtual tinkering environment.

The subject of this research could be explored to a greater extent of participants and time and could include a bigger variety of tools that include virtual tinkering (e.g. robotics, programming etc). By observing a larger number of groups a statistical analysis tool could be used for the description of the differences between the groups (e.g. non-parametric Kruskal-Wallis test). Another important aspect that could be investigated is the nature of support among students and teachers, as well as future research could focus on learning outcomes resulting from support to virtual tinkering environment using pre and post-tests. The way also in which individuals assess the needs of others for support could even be investigated, in order to eliminate cases of “over” or “under” scaffolding, using specialized measurement models, such as the Gradual Release of Responsibility Model.

Conclusion

The results of this survey are quite encouraging regarding the picture given of a constructionism learning theory environment, specifically for the nature of social scaffolding in a virtual tinkering environment. Taking advantage of tinkering’s benefits, participants entered a repetitive cycle of de-construction and re-construction of their product, seeking, receiving and giving support. Through constant dialogue, they evaluated and implemented new ideas in order to reach the desired result for their construction.

The contribution of this study relies to the general description of the phenomenon of social scaffolding during virtual tinkering. Given the lack of empirical research for this subject, the effort seems to have yielded an overall picture which could be the basis for future research.

ISBN 978-615-5511-06-6

Although in this case there is a limitation to descriptive presentation of the results, extensive research in the future could make use of specialized support measurement models and statistical analyses for this phenomenon.

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

COMPUTER SUPPORTED COLLABORATIVE LEARNING IN SMALL TEAMS FOR SCRATCH: PROGRAMMING SKILLS FOR YEAR 4 STUDENTS AT THE 6TH PRIMARY SCHOOL OF PATRAS, GREECE

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Abstract

Teaching programming skills in Year 4, 10 years old students in Greece in a period of crisis is a great challenge. Code Club Scratch programming skills, an initiative supported by the British Council was successfully implemented for one year at the 6th Primary School of Patras. Final year graduate students in computer science from the University of Patras taught the 2 hours a week course on a voluntary basis. A greater challenge was the inclusive character of the school which was turned into an advantage for both teaching staff and students. The students created their own game using the jigsaw puzzle game development methodology after trying several team organisation techniques and were able to create their own interactive games and discover the fun game development element.

Introduction: Scratch Programming in Primary Schools

Education today cannot be separated with the ICT based activities and learning technology. Students' creative and critical thinking, collaboration and fun have also fundamental role in developing kid's creativity, innovation and logic; programming therefore is an essential part of any educational system. Teaching programming languages to kids influences their way of thinking while personal fulfilment and development is achieved. A solid yet fun way of introducing children to programming is the development of a video game. Developing video games is a useful method for programming promotion, as it is seen by some to be a highly motivational and practical approach at engaging children at Primary Education level in computer programming concepts.

This pedagogical method was constructionism; the young student is the protagonist of the learning process, and he or she learns by doing.[5] During a game's construction students have to understand how things fit together, which improves their logical skills. As soon as they succeed while creating something (anything) they instantly get motivated. Therefore, reaching students through technology assisted teaching, which may include games and digital tools with pedagogical value, not only fosters their imagination, intuition and helps them develop an inquiring mind, but also the ability to cooperate and solve problems. It is therefore important for each child's development and learning, especially in the early years.

Code Club [1] was created to promote teaching programming languages to kids. Code Club is a nationwide network, originated in Britain, which allows volunteers to teach children aged 9-11 the basics of programming. This includes Terms I and 2 with Scratch [2], Term 3 teaches the basics of web development using HTML and CSS and Term 4 teaches Python and relative programming languages. The lessons take place either in after-school coding clubs or at non-school venues such as libraries. Volunteers teach children programming according to the projects that Code Club gives them. These projects include video games, animations and websites. In this way, each student feels that he or she is the protagonist of the learning process and learns by doing.

The goal of these projects is to inspire children to pursue other creative activities. To gain skills that can be proven useful to them in many areas, but most importantly learn about computational thinking, problem solving, planning, designing and collaborating with others. Code Club provides opportunities for every student in the classroom to unlock their creative or innovative potential and to develop their digital competence through lifelong learning. In this school year Code Club in agreement with the 6th Primary School of Patras, taught students a course of programming projects using Scratch programming language [3]. The participation of the teachers was solely volunteering and for the 4th grade in the 6th Primary School of Patras, the volunteers were all students in the Department of Computer Engineering in University of Patras. [4] Teachers play a significant role stimulating children's curiosity, imagination and willingness to perform experiments and helping them develop not only basic skills and specific knowledge, but also the transversal competences required for creativity and innovation, such as critical thinking, problem-solving and initiative-taking. Their role as a teacher extends beyond setting the challenge and providing support in projects, to helping pupils understand the ideas that lie at the heart of the creative work in which they're engaged, and finally helping them make the connection between these concepts.

Research results suggest that the use of game construction tools in the primary classroom can be very useful a tool in introducing children to programming. [6][8]. At the start of each lesson, teachers show all the pupils what they would do next – on a whiteboard – at the front of the class. Then they go to work in pairs at the computers, trying to achieve the same task using Scratch. Similar work has been done combined use of Scratch and WeDo in the creation of robotic projects. [5][10].By the end of the educational year, it was observable that individual members could have produced games on their own and were able to create and debug their own programs using their imagination and expanding their creativity, as well as using technology safely and respectfully. The part that our work that differentiates is that not only at the end of the year students were able to create their own games, but the entire class worked as a team and a game was created from all the students, implementing a Generative Topic and utilizing the Jigsaw Puzzle technique. This game development led the slitting of the class into 4 teams: Coding, Drawing, Sound and Story. In this way pupils improved their co-creativity, self and group organization and a collaborative learning environment was created in the class.

ISBN 978-615-5511-06-6

Programming at schools is considered important and for this reason, different kinds of teacher's guides have been written especially for primary teachers, in order for them to be able to teach programming in a meaningful way. Guides may include help for schools with planning and gives guidance on how best to develop teachers' skills. [7].

The 6th state primary school of Patras

The 6th state primary school of Patras is located in the city centre of Patras, the third largest city of Greece. There are a large number of economic migrants mostly coming from Albania and Eastern Europe as well as other students from underprivileged families. Migrants mostly speak their native language at home so they hardly speak and understand Greek. Students with learning problems are also welcomed; there is a special class where these students are invited for support while attending their class school timetable. The social status of our students' families varies. Some come from highly educated families whereas others lack basic knowledge and opportunities. Therefore, students do not have the same educational opportunities as with other Greek schools; the socio economic European crisis is one of the reasons our students' families experience difficulties.

The school also has a modern IT room with an interactive board for the teachers to engage the students in the learning activities. Hence, one of the main objectives of the school is to embrace culture and support for the students and their learning and socio-cultural needs throughout the study course. Consequently, a sense of community belonging and active citizenship are enabled and supported with the school community as well as the local and regional communities; diverse participatory learning and collaborative as well as socially-inclusive activities on a school, local and regional level. [4]

Computer Supported Collaborative Learning (CSCL)

The suggested pedagogical methodology was anchored in constructionism, Computer Supported Collaborative Learning (CSCL, 15, 16) in small teams for Generative Topic and utilising the Jigsaw Puzzle technique. In CSCL this technique refers for different group members working on different part of the project. Then the project is brought together and is switched to the collaborative approach. Here, the students bring coherency in the project by working all together in all project parts. Constructionism [17] is a theory of learning and a strategy for education that evokes the idea of learning-by-making. Constructionism is learning by Design and opposes instructionism when discussing directions for innovation and enhancement in education. Collaborative learning (by UNESCO [18]) takes place when learners work in groups on the same task simultaneously, thinking together over demands and tackling complexities. Collaboration is here seen as the act of shared creation and/or discovery. Within the context of electronic communication, collaborative learning can take place without members being physically in the same location.

ISBN 978-615-5511-06-6

Collaborative learning revolving around the generative topic of Scratch programming enhances students' understanding, knowledge, skills and competencies acquisition in action successfully in related CodeClub projects. Teaching by Generative Topic is open teaching following a plan however, without strict use of resources so both the students and the teachers can explore the subject to their interest. Thus, different techniques and methods can be utilised and tried out for the best practices to appear for the specific context and situation, also expanding it to students' own context such as programming in their own time for their own purposes. Such synthesis of formal and informal learning and also, onsite and online simultaneously was facilitated by the IT Room, in this case donated by Niarchos Foundation.

The students were organised in small teams to provide specific and common purposes and targets, share responsibility, measure their progress, synthesize their complementary skills, agree on the norms and rules, agree on practices and processes to follow for a successful project to mention a few. Such team creative flow building target sat conflict resolutions, team project realisation, acknowledge each other's abilities and skills, build relationships of trust and support; otherwise the project will fail. During the first meeting with the Code Club volunteers there were team building techniques such as 'catch the ball' and introducing themselves, what they do and interests. Also, an agreement on norms and behaviours was established. As for a class project in order to participate in a major national competition on Scratch in March 2015, the students agreed to participate.

During the first class project meeting the students were split into two groups selecting a different project game, the circus and the cemetery. Such division created a major competitive climate in the classroom so we, the teachers, decided to change methodology. For this we utilised the Jigsaw Puzzle CSCL technique build upon the game development real expert roles as in the industry. A new project called The House of Horror was selected, combining the two previous teams' ideas. In this way we ensured students' complementary successful participation also targeting at the realisation that one groups cannot work without the other, these were the scenario, the drawing, the music and the programmers group. The team projects was built on: i) team culture, the leverage of expertise of others based on everyone's expertise and advance on others; ii) the shared desire and meaningful ideas to each member; iii) each member's significant contribution; iv) a wide spectrum of expertise for the primary school students; and v) students' full brain utilisation and imagination in a very short period of time. Then the project was pulled together by all students' participation. The next section describes the exact process for game development, for year 4 (10 years old) students.

The Game: The House of Horror

The Game development stages were the following:

- **Part One: The frightening brainstorming power of a class of 10-year-olds.** This was quite interesting I believe for both parties involved (the students and ourselves) seeing a mayhem of ideas flying all over the room, trying to harness this raw creativity and guide it towards a feasible goal in the deadlines we were given with the resources we

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had. I mean, that's something all projects face, but try telling an enthusiastic child his idea is probably not going to be in the final demo. It wasn't all about hard decisions though, we had a lot of fun listening to all sorts of features and artistic directions for the game until we concluded to a game about a Haunted House in which the player has to follow clues in hopes of finding out the hidden treasure.

- **Part Two: The design & team splitting.** This one went a bit smoother than the brainstorming part, we got all executive and managerial and decided to split into 4 teams: Coding, Drawing, Sound and Story. Most kids found where they fit and seemed to have a blast with what they were supposed to do and some of them turned out to be exceptional..!
- **Part Three: 9 to 5.** With all our structures and fancy designs in place all that was left to do was do the actual work - on an average session you would see kids having a go at flow diagrams, furniture sketches, creepy ghostly laughs and cute little riddles - all of the above being formed alongside their team members. It's impressive in my eyes, given these were kids who, albeit talented, had never before tried putting their skills towards creating an actual game. Sure, we did guide them throughout the process, but it'd be a lie to say they didn't do all the heavy lifting.
- **Part Four: Are we there yet?** At some point we experienced a saturation, almost a halt. In my experience, this is the most crucial part of game development and possibly of any artistic project. It's when you feel that all the hard work you've put in hasn't got you as far as you were 'supposed' to go, any additional work you perform feels like isn't helping either and you're getting tired, sad and even angry. This is, I believe, where it could have all gone wrong and the project left unfinished. Thankfully, the kids had their guardian angels. Their teacher and a couple of understanding individuals from our team managed to inspire them to keep calm and carry on with the show. How they managed that is beyond me - it's just something good teachers are good at.
- **Part Five: Missing a piece from your puzzle?** Well thankfully not. When the time came (deadline day) all the parts were accounted for, tested and at an exceptional level of completion. Putting them together was where we all chipped in, and admittedly the only phase we actively helped the children. It was chaos - there were USB sticks flying around, children feverously cropping art assets to remove individual backgrounds, files were being over-versioned to ensure nothing was lost, all assets were being converted to the required formats and lots of technical fine tuning that was required to showcase the kids' hard work. And showcase we did.
- **Part Six: The House of Horror.** When the dust settled, we were left with one fun little game called The House of Horror. Created by a class of very enthusiastic and creative ten-year-olds with the stomach to see a tough project all the way to the end. You can play the kid's game in its final version here: [23]
- **Part Seven: The end..?** When our little adventure came to an end, we were left with a class full of students (not just the ones who created the game) eager to play House of Horror on the classroom's big screen. Teachers too..! So the result can only be described with one word – Success.

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This experience is something amazing for students and teachers alike. Most of us would try it again - even if two dozen kids creating art can be quite the handful some times.

Students' Comments and important observations

Students were really surprised from their game result and after asking them to tell us their experience; some of their comments were the following:

> *"I liked that we all worked together" – Diana*
>
> *"It was perfect..!" – Nicolas*
>
> *"We made a game!!" – Dionysius*
>
> *"I drew and others were speaking in microphones and others were using computers and others were writing riddles and we all worked as a team" – Charalambos*
>
> *"I solved many problems it was very fun!!" – Eftixia*

Many students created their own games at home, visited the CodeClub website to download more advanced learning material and collaborated between them for more games. Eftixia has created birthday cards for her mother's birthday and other relatives and advanced on Scratch programming on her own as with most students. It was also impressive that the students were taught advanced concepts' in mathematics taught in High school in Greece. For this we used spatial metaphors and role play games to represent the temporal and special connection in space as with the computer interface.

Concluding Remarks and Future Work

This paper presented teaching and learning Scratch programming for Year 4 students. We were very pleased with the entire experience and believe that this way of teaching programming was both satisfying and rewarding for the kids. In more detail, as can be seen in the previous parts of this paper, the students were divided into specific groups (programming, drawing, music and writing) based on their preferences and united by a common goal – create an entire video game from scratch. This was a very important step since we could always count on the fact that they were being occupied by things that they liked – which made the whole project much more fun and easy to handle. Concerning the programming team, which is the main focus of this paper, we can definitely say that the kids successfully identified, solved and implemented a number of increasingly complex logical, organizational and even cross-specialty problems since every other asset (Drawings, Music, Text) had to end up inside the final program.

They were also exposed to a few core values of programming (both serial and object-oriented) – from loops and if clauses, to objects working in parallel and event send and handling. These were not taught on a theoretical level. Instead, they were explained via examples both in-code and using little games (events were passed in the form of notes between students, the importance of a for loop was explained by letting them imagine all the work they would have to do if they were not allowed to use one, etc..). Having been taught programming by a handful of teachers, it's our firm belief that actively engaging students when teaching them any programming language does wonders. Concerning the future, we were happy to be told by the school that they would love to continue down this path we laid last year, perhaps with more volunteers, teachers and students involved. It would also be great getting together with other specialists, refining our teaching procedures and forming an even better plan for the years to come. As for research, we will be able to study the effects of this year programming skills on next year in time length and on a deeper level.

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Acknowledgments

We are thankful to the Year 4 students: Alexandros Athanasiadis, Anastasopoulos Stylianos Nikolaos, Gasparinatos, Giannopolitis Charalambos Gieris Diana Daria, Zacharopoulou Isabella, Castanas Dionysius, YiannisKarfitsas, KatsarosNikolaos, Lanai Nicolas-Orlando, Marketou Eftixia, Mata Alexander, Mouzoukos Michael, Dogan Argela, Duma Dora, Papadopoulou Marina, Paparrigopoulos Anthony, Pitsapidoulas George, Spyrou Andreas, Spaliaras Dionysia, Tsakai Grisa, Chalkidi Iphigenia,Hatzigiannis Alexandros, Christidis Myrto and the 6th Primary School of Patras [4].

ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

VISUALISE AND EVALUATE INTERACTIONS OF STUDENTS IN ONLINE DISCUSSION FORUMS

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Abstract

Information and Communication Technologies (ICT) have been widely used in educational institutions to enhance student learning both within and outside the classroom. Recent technological advancements have made it possible to access real-time student data and evaluate performance of students. Monitoring of student social networks assists instructors in identifying student isolation and community formation. The Social Networks Adapting Pedagogical Practice (SNAPP) tool assists instructors to extract and visualise students online network interactions resulting from discussion forums posts and replies.

This study aims to visualise and evaluate interactions of students in online discussion forum which was used for project collaboration. Online discussion forums were integrated into a postgraduate course at Cyprus International University (CIU) and students were asked to discuss course and term project related topics on the forum. Then, their interactions were examined with SNAPP tool which, helps to visualise and analyse student data to provide suggestions to promote discussions in courses.

Introduction

Online discussion forums can be a good equaliser tool in a blended classroom that provides all students an equal opportunity to make their thoughts known and to respond to others. Students can read a post, take time to reflect, and make a thoughtful response when they are prepared to do so (Murphy & Fortner, 2014). Instructors can monitor discussions that are happening between students and identify well understood topics as well as the topics that need to be addressed more with the use of online discussion forums (Wang & Chen, 2008).

In an online discussion environment, students can also escape the restrictions and inhibitions involved in a face-to-face environment. Mixing of online and face-to-face communication can encourage the development of new and energising thoughts (Murphy & Fortner, 2014). Sharing and discussion of ideas can assist students to get connected with the subject matter (Brookfield & Preskill, 2013).

It is important for an instructor to integrate and promote the use of online discussion forums to improve student collaboration and understand how students are interacting. However, native discussion tools are limited in their ability to show interactions patterns among students. Therefore, this study aims to visualise and evaluate student communications through the use of social network interactions on online discussion forums implemented in Moodle by using of SNAPP. In total, 38 students were registered to the course, however only 23 of them used discussion forum to discuss and share ideas about their course projects and only 4 of them used forum to discuss course related topics. Results showed that students tend to participate in discussions more when the discussion is lead and facilitated by lecturer.

Learning Analytics

Learning analytics is measurement, collection, analysis and reporting of student data used by instructors to understand what is happening within a learning environment. Learning analytics helps to estimate, accumulate, examine and report information on students and their surroundings, for the purpose of evaluating and improving learning and environments (Blikstein, 2011).

Social learning analytics refers to the use of online data generated by students and helps to identify behaviours and patterns within the learning environment. This can be used by institutions, instructors and students for recommendations that inspire and support learning. These social analytics collected when students are socially engaged through direct interaction, particularly dialogue and indirect interaction (Buckingham Shum & Ferguson, 2012). A strategy that is used for evaluation of social interactions called Social Network Analysis (SNA). It characterises network properties such as density, centrality, connectivity, betweenness and degrees with the use of concepts from networks and chart theories. Collection of such measures provides a visualisation of observed patterns that occur during social communications and interactions. In an online learning environment students can socially communicate through discussion forums or chat tools (Dawson, Macfadyen & Lockyer, 2009). SNA tools automates the process of visualisation, extraction and evaluation of student network data by rapidly presenting network information that is directly usable by instructors (Elias, 2011).

SNAPP

Social Networks Adapting Pedagogical Practice is a tool that permits instructors to envision the connections coming from forum discussion posts and replies. The tool visualises the communications among students and provide an opportunity to quickly recognise examples of student interactions. SNAPP has been created to extract all student collaborations from different commercial and open source learning management systems (LMS) such as BlackBoard, Sakai CLE and Moodle. SNAPP is implemented as JavaScript booklet and can work with various internet browsers including Firefox, Chrome and Internet Explorer (Dawson et al., 2009).

Data about collaborations happening among instructors and students gives fast distinguishing proof of the levels of engagement. The social network diagram provided by SNAPP can be used to identify isolated students, potentially high and low performing students, students that bridge smaller clustered networks and serve as information brokers, and provide pre- and

ISBN 978-615-5511-06-6

post-learning interventions, which is useful indicator of reflective teaching practice (Bakharia, Heathcote & Dawson, 2009).

SNAPP has numerous features and analysis of the forum postings provide information on the total number of posts, the number of posts per user, the average number of posts and social networking centrality measures. In addition, posting frequency table lists the number of posts and replies to posts made by each student and which student is having a conversation with whom and if the student is connecting different groups through the network diagram (Dawson et al., 2009).

Application of SNAPP and Results

In Cyprus International University, Moodle LMS is commonly used to deliver course materials, collect assignments and communicate with students. However, in order to facilitate student collaboration and interaction, a discussion forum was integrated into Management Information Systems postgraduate course. Students were allowed to use this forum for half a semester to share and discuss ideas about their project topics. At the end of the semester, student interactions were investigated with SNAPP tool and a network diagram is created (Figure 1). As it can be observed in total 23 student participated in this discussion.

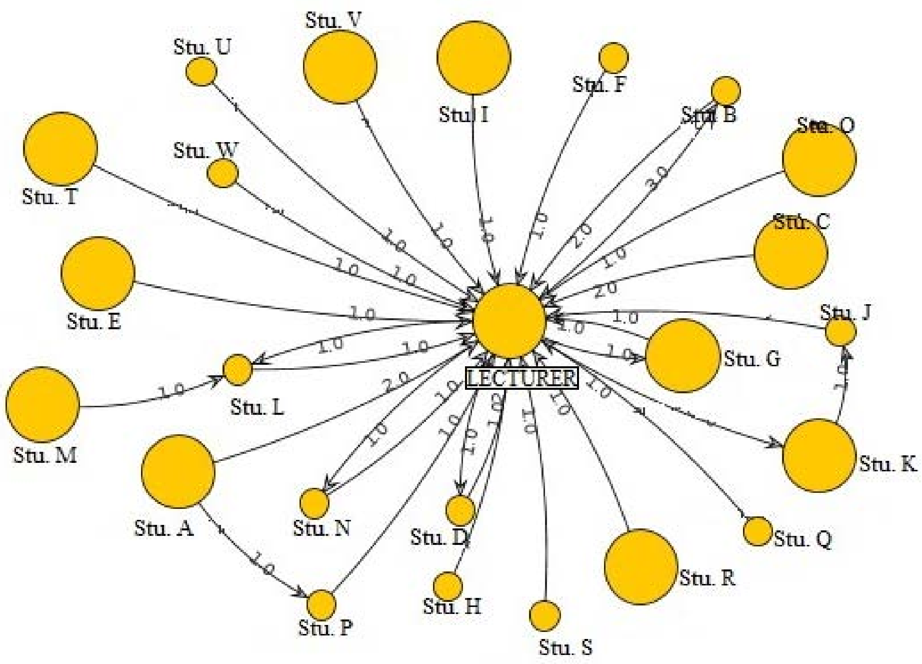

Figure 1. Social network diagram of student interactions for discussions about their projects

The circles in Figure 1 represents students participated in this discussion and numbers on directional arrows represent number of posts. This discussion was instructor-led and it can be observed that all students connected to instructor and post a discussion at least once. However, there are little interactions among students when facilitator is lecturer. Students who are actively involved in this discussion are Student A and Student B.

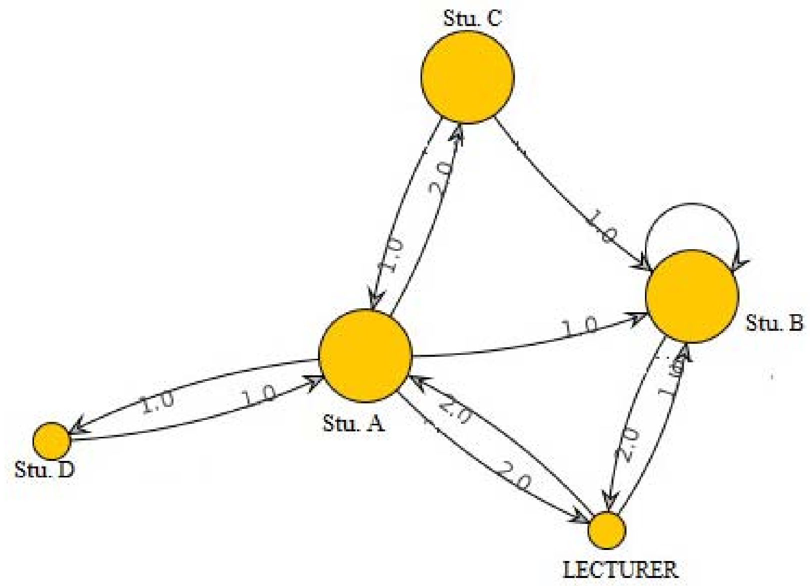

Figure 2. Social network diagram of student interactions for course related topics

In a discussion that is lead by a student (Figure 2), it can be observed that students interacting with each other more, while lecturer is only peripherally involved.

Conclusion

This study intended to show how a social learning analytics tool can be used to visualise and evaluate student discussions. SNAPP tool can be used to analyse and improve student interactions for group projects. Lecturers can clearly see communications among students and encourage or support them for collaboration. Application of this tool in this course will encourage other lecturers to use this tool as almost all postgraduate courses in CIU involve group projects. On one hand, the tool can support course development by evaluating structure of discussions. On the other hand, it can promote student development as lecturers can provide feedback in terms of their performances on discussion forums.

ISBN 978-615-5511-06-6

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

A NETWORK OF PEERS AND PRACTICES FOR ADDRESSING LEARNER VARIABILITY: UDLNET – THE CASE OF SCIENCE TEACHING

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Abstract

Article 24 of the UN Convention on the Rights of Persons with Disabilities states that persons with disabilities should be guaranteed the right to inclusive education at all levels, regardless of age, without discrimination and on the basis of equal opportunity. State Parties should ensure that children with disabilities are not excluded from free and compulsory primary education, or from secondary education. Still, there is a long way ahead before reaching a society where equal opportunities are guaranteed for all. Inclusive and quality education is a key means to achieve this goal. In many special, as well as mainstream schools, however, there is still much uncertainty and a lack of knowledge. Grounded on new research in neuroscience and the Design for All principles, Universal Design for Learning constitutes an educational approach that promotes access, participation and progress in the general curriculum for all learners. UDL recognises the need to create opportunities for the inclusion of diverse learners through providing curricula and instructional activities that allow for multiple means of representation, expression, and engagement. Yet, these developments do not necessarily result in significant, widespread changes in practice – that is, in how schools actually organise and provide learning experiences for pupils. The difficulty is in all cases translating these policies into practice. Though the policy context supports a shift to inclusion, professionals need more support to develop their practice. In order to bridge the gap between policy and practice the UDLnet network aspires to address this necessity collecting and creating best practices under the framework of Universal Design for Learning. UDLnet is a European network that aims to contribute to the improvement of teachers' practice in all areas of their work, combining ICT skills with UDL-based innovations in pedagogy, curriculum, and institutional organization. This paper presents the UDLnet project, its aims, the methodological framework, as well as the description and documentation of a case study from the field of science with application of the UDL framework on the Inventory.

Keywords: Universal Design for Learning (UDL), Design for All, inclusive education, science, inquiry base science education (IBSE)

Introduction

Following the European Year for Combating Poverty and Social Inclusion (2010), the adoption of a headline target under the Europe 2020 Strategy (Europe 2020, 2010) on the reduction of early school leaving and the 2010 Council conclusions on the education of migrants and on the social dimension of education and training, social inclusion is promoted through education. For the school sector particularly, the issues of early school leaving and special needs are particularly important. European legislation addresses disability in a broad range of areas: Treaty of Amsterdam (Article 13, 1997) on discrimination against disabled citizens; Article 26, EU Charter of Fundamental Rights on 'the right of persons with disabilities to benefit from measures designed to ensure their independence/social and occupational integration/participation in the life of the community.' Mainstreaming accessibility in EU policies is part of the Commission's wider drive to facilitate people with disabilities to play their full part in society. Disability is also at the core of the UN Convention on the Rights of People with Disabilities, to which the European Community is a signatory. The EU's Europe 2020 strategy has, as a priority, accessibility and economic/social participation of people with disabilities through the elimination of existing barriers. According to the EU Commission Staff Working Document Analysis and mapping of innovative teaching and learning for all through new Technologies and Open Educational Resources in Europe Accompanying document Communication 'Opening Up Education' (2013), the wider use of new technology and open educational resources can contribute to alleviating costs for educational institutions and for students, especially among disadvantaged groups. This equity impact requires, however, sustained investment in educational infrastructures and human resources

The right to inclusive and quality education for all, has come a long way over the last decades. Since the UNESCO Salamanca Statement of 1994, there is a political will within the 27 EU Member States to carry out the necessary changes in the field of legislation and school organisation. Both on European and national levels, authorities worked on the realisation of legal frameworks facilitating inclusive education for all within the framework of their competence. These declarations and policy documents clearly state that all children and adults have the same right to high quality and appropriate education. While there have been numerous successful efforts to reduce barriers to access, participation, and progress within the general education curriculum, students with disabilities still experience significant difficulty obtaining accessible and usable educational resources in a timely manner. As a result, students with disabilities are chronically at high risk for school failure and under-performance (Blackorby & Wagner, 2004; Frieden, 2004). The challenge, according to Universal Design for Learning (UDL) is not to change the students, but rather to redesign, adapt and personalize curricula and instructional methods and create a learning environment that helps each student develop his or her full potential. Thus, Designing for All (D4All) and promoting inclusion benefits all children and not only those with disabilities.

ISBN 978-615-5511-06-6

State of the art

What is Universal Design for Learning?

Grounded on new research in neuroscience (Hall, Meyer & Rose, 2012) and the Design for All (D4All) principles (Stephanidis, 1999), Universal Design for Learning (UDL) constitutes an educational approach that promotes access, participation and progress in the general curriculum for all learners (CAST, 2015). Individuals bring a huge variety of skills, needs, and interests to learning. Neuroscience reveals that these differences are as varied and unique as our DNA or fingerprints. Three primary brain networks come into play: (Meyer & Rose, 2000; Rose & Meyer, 2002; 2006):

Table 1: Brain networks and Universal Design for Learning

Affective Networks	Recognition Networks	Strategic Networks
The "why" of learning	**The "what" of learning**	**The "how" of learning**
How learners get engaged and stay motivated. How they are challenged, excited, or interested. These are affective dimensions.	How we gather facts and categorize what we see, hear, and read. Identifying letters, words, or an author's style are recognition tasks.	Planning and performing tasks. How we organize and express our ideas. Writing an essay or solving a math problem are strategic tasks.
Stimulate interest and motivation for learning	Present information and content in different ways	Differentiate the ways that students can express what they know

UDL recognises the need to create opportunities for the inclusion of diverse learners through providing curricula and instructional activities that allow for multiple means of representation, expression, and engagement (King-Sears, 2009; CAST, 2015).

The Three Principles

Three primary principles, based on neuroscience research, guide UDL and provide the underlying framework for the Guidelines:

- **Principle I: Provide Multiple Means of Engagement** (the "why" of learning). Affect represents a crucial element to learning. Learners differ markedly in the ways in which they can be engaged or motivated to learn. There are a variety of sources that can influence individual variation in affect including neurology, culture, personal relevance, subjectivity, and background knowledge, along with other factors presented in these guidelines. Some learners are highly engaged by spontaneity and novelty. Others are disengaged, even frightened, by those aspects, preferring strict routine. Some learners might like to work alone, while others prefer to work with their peers.
- **Principle II: Provide Multiple Means of Action and Expression** (the "how" of learning). Learners differ in the ways that they can navigate a learning environment and express what they know. For example, individuals with significant movement impairments (e.g., cerebral palsy), those who struggle with strategic and organizational abilities (executive function disorders), those who have language barriers, and so forth

ISBN 978-615-5511-06-6

approach learning tasks very differently. Some may be able to express themselves well in writing text, but not speech, and vice versa. It should also be recognized that action and expression require a great deal of strategy, practice, and organization, and this is another area in which learners can differ.

- **Principle III: Provide Multiple Means of Representation** (the "what" of learning). Learners differ in the ways that they perceive and comprehend information that is presented to them. For example, those with sensory disabilities (e.g., blindness or deafness); learning disabilities (e.g., dyslexia); language or cultural differences, and so forth may all require different ways of approaching content. Others may simply grasp information quicker or more efficiently through visual or auditory means rather than printed text. Also, learning and transfer of learning occur when multiple representations are used, because it allows students to make connections within, as well as between, concepts.

The UDL Guidelines (CAST, 2011) are organized according to the three main principles of UDL. The principles are broken down into Guidelines, which each have supporting checkpoints (CAST, 2015).

The UDLnet network

In order to bridge the gap between policies and practice in applying UDL and to face the associated obstacles identified above, we present here the design and development of the UDL Network (UDLnet). UDLnet aspires to address the necessity of collecting and creating best practices under the framework of UDL from a wide range (generic guidelines down to more specific ones) of four envisaged themes: inclusive learning environments, accessible resources, teachers' and school leaders' competences, examination of barriers and identification of opportunities. UDLnet targets 3,500 users in seven countries across Europe (Greece, Ireland, Cyprus, Finland, Netherlands, Germany, Spain). In general, UDLnet aims to improve teachers' practice in all areas of their work, combining ICT skills with UDL-based innovations in pedagogy, curriculum, and institutional organization. It is also aimed at in-service and pre-service teachers' use of ICT skills and resources to improve their teaching, to collaborate with colleagues, and perhaps ultimately to become innovation leaders in their institutions.. The overall objective is not only to improve classroom practice, but also to raise awareness of the European educational community on the need for UDL based teaching and learning practices.

The envisaged procedure of UDLnet Network consists of the following basic phases:

- **Good Practice Thematic Search and Organization:** good practices shall be collected from partner countries, as well as from affiliated institutions in the areas of inclusive education all over Europe with emphasis in UDL, through focus groups, as well as through the practice exchange forum.

- **Implementation:** a number of events shall be organised for the exchange, validation and evaluation of the collected UDL best practices: such as training sessions, contests, summer schools, webinars, as well as workshops organized in local and European level.
- **Valorisation:** The formation of a set of recommendations to policy makers and regional authorities shall indicate ways European policy makers can use the UDLnet Inventory and UDL good practices to support the inclusive education and training of their citizens.

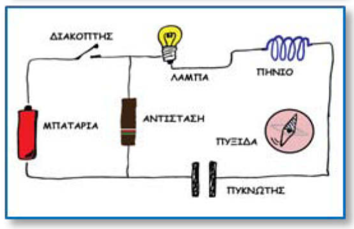
UDLnet Practices – case study from the field of science

In this contex we present three educational scenarios from the field of science education along with the application of the UDL guidelines as documented on the UDLnet Inventory.

A didactic proposal to introduce the concepts of "energy flow", "wave", "oscillation" and "disorder"

Inquiry learning aims at students in pursuiting of scientific procedures and practice of science in the context of scientific literacy. The central idea of the inquiry learning is the formulation of educational, "simple" scientific questions to be explored by scientific method. We chosen the 7E model (Levy et al., 2014) since – in out scenarios – the Extend sub-phase is a very important phase for deep scientific understanding of core ideas and the development of everyday life skills.

Table 2: 1st didactical hour (introduction – flow), the 7E model's phases

Phase	Activities	Figures
elicit	Recall the analogy "water cycle ≈ DC electrical circuit", Recall of Energy Chains (Nerantzis, 2014b; Tiberghien, Baker & Brna 1999). Students wonder on "What is a flow? " & "Flow equals motion?	
engagement	Students, list, record and classify flows in the analogy and at the energy chains, highlighting the globality of the concept "flow" and the fact that "behind" of mass and electrical charge flow(s) are energy's transformation(s) & conventions. Activity # 1: - observing and describing movements of 1D coupled pendulums. The teacher "elicits" the concept of the "wave", highlighting the fact that the bodies are in motion but not in locomotion.	
exploration	Activity # 1 (continuation): The teacher "elicits" the concept of the "wave", highlighting the fact that the bodies are in motion but not in locomotion.	
explanation	Group discussion & discussion in the whole class	
elaboration	Observation/Conclusions	
evaluation	Review, Metacognition	
extend	Homework: On "flow", students are to collect material from books, magazines or the Internet, to list and present flow(s) and wave(s) behaviour and to record views and queries.	

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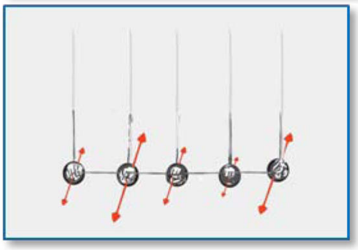
		 

Except IBSE in the present scenario the use of analogies are very useful. The use of analogies plays a vital role in the educational process in general and in approaching and building concepts. Analogies proven to be a valuable and direct tool allowing, for example, direct import of abstract concepts' representations. The analogies and models are useful tools of thinking, representing (but not copying) a piece of reality. The successful use of analogies requires adequate preparation of the students (Aubusson et al., 2006).

Table 3: 2nd didactical hour (on waves & oscillations), the 7E model's phases

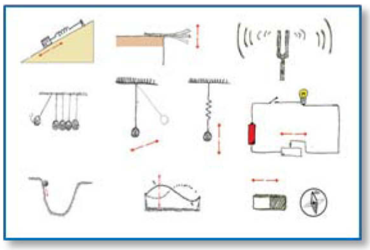
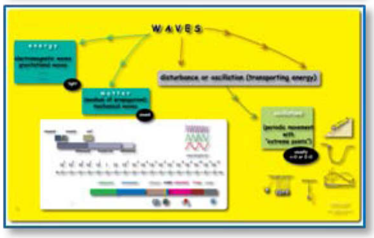
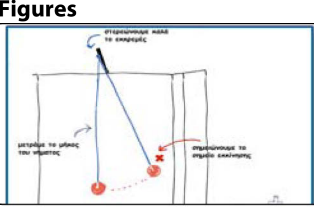
Phase	Activities	Figures
elicit	Review of 2nd didactical hour, use of storyline and posters. Students wonder on "What is a wave? " & "Can we see/observe waves of matter & waves of energy?"	 
engagement	Activity # 2: Observing, listing and describing movements of 2D & 3D coupled pendulums. Activity # 3: Implementation of an experimental setup for waves/oscillations.	
exploration	Activity # 3 (continuation): Listing & describing waves/oscillations. Matter ≈ energy analogy. Distinction between mechanical electromagnetic waves. Highlighting the difference mechanical waves ≠ matter flow(s).	
explanation	Group discussion & discussion in the whole class. Use of poster on waves/oscillations	
elaboration	Observation/Conclusions	
evaluation	Review, Metacognition	
extend	Homework: Students will contact an inquiry (in sources such as books, magazines or the Internet, etc) for other uses of the word "wave" and / or "oscillation" and they will express opinions and questions. They have also to draw the Activity's #3 setup energy chain (diagram).	

Table 4: 3rd didactical hour (inquiry: experiment & measurements), the 7E model's phases

Phase	Activities	Figures
elicit	Review 2nd didactical hours, use of storyline and posters. The scientific question for the inquiry is "Does the pendulum's period depends on its mass? – Justify your answer"	
engagement	Design an experimental apparatus (pendulum) in order to observe and measure	
exploration		
explanation		

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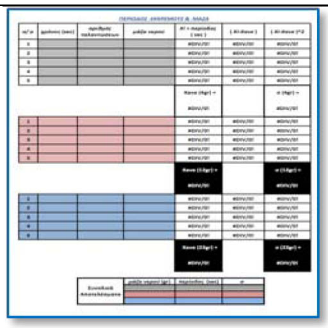
elaboration	Activity # 4 Implementing an experimental apparatus in order to observe and measure. Activity # 5: Taking measurements (time, number of oscillations, mass), Observation/Conclusions	
evaluation	Review, Metacognition	
extend	Homework: Students will write a small text on commenting the results of the experiment.	

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Table 5: UDL principles (flow)

UDL Principle I: Information/Instruction offered in different ways
1st Guideline: Relevant information is available on the learning objectives and outcomes • in advance • at any time • temporarily • on demand ***How this guideline was implemented:*** visual aids, posters, artifacts, PC/laptop ***2nd Guideline: Information can be assimilated in various ways*** • visual ***How this guideline was implemented:*** via posters & worksheet **3rd Guideline: The understanding/comprehending of information is supported by providing various options** • illustrations • practical demonstration ***How this guideline was implemented:*** students have the opportunity to inquiry & experiment
UDL Principle II: Allow the learners to express what they know in different ways
4th Guideline: Learner can actively work with the learning materials in different ways • individual work • group work • discussion ***How this guideline was implemented:*** *students are working in small groups but they have also the task to discuss/present their work is the classroom * homework usually is an atomic task ***5th Guideline: Learners can show the results of work as ...*** • textual description • individual oral report • group presentation ***How this guideline was implemented:*** students have the flexibility to demonstrate the outcomes of the activities in a variety of ways (text, presentation, graph/sketch, etc) ***6th Guideline: There are different forms of support provided such as ...*** • face-to-face mentoring ***How this guideline was implemented:*** the support is (primarily) takes place at the classroom by face-to-face mentoring
UDL Principle III: Learners are engaged and motivated in different ways
7th Guideline: Different known interests and motivators are addressed such as ... • personal interests • authentic tasks • choice in context ***How this guideline was implemented:*** the scenario "negotiates" basic physics' concepts (such as field, energy, gravity, etc) with educational tools which always move students' curiosity. ***8th Guideline: Interests and goal attainment as well as resilience are stimulates actively by ...*** • clear goals • practical relevance ***How this guideline was implemented:*** students have the opportunity to run inquiries & hands on experiments themselves on waves/oscillations ***9th Guideline: There are opportunities for self-regulation provided ...*** • creative freedom • organizational flexibility • beneficial learning environment • independent diagnosis and assessment of the finished learning process ***How this guideline was implemented:*** students' metacognition is supported with the use of specific directions for every activity and at the evaluation phase (metacognitive questions at the worksheet)

Posters as educational material

Posters are visual tool that can be part of many lesson plans and activities (e.g. as an advance organizer, as a common reference content, a resumption material, a cross thematic material, etc.), fitting students' educational needs, maximizing the success of educational objectives and combining – at the same time – images, text, mathematics and sketches (Nerantzis, 2014a). Posters are also a visual tool that can "give readers a spark of excitement and results in a new level of understanding" (Steele & Iliinsky, 2010).

ISBN 978-615-5511-06-6

Figure 1. MSKSTON for "I", "take", "give", "drink" from http://logo-center.gr/site/?p=581

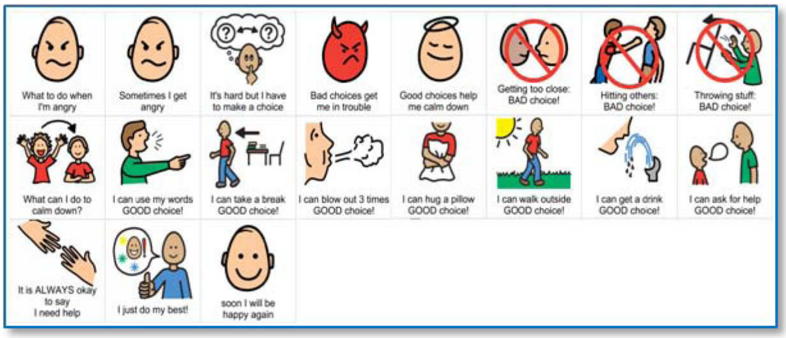

Figure 2. A social story for educating children with autism spectrum disorder (DSM-5), http://autismsupportnow.com/wp-content/uploads/2012/12/copingwithfeelings.pdf

By placing those posters in the classroom, helps students to remember, to transfer knowledge from one subject to another and on their metacognitive skills, to control/check their knowledge (Zohar & Dori, 2012) and – if the students are appearing in the poster – there is a positive effect on their self-esteem (Nerantzis, 2014a). "The most important part of understanding data is identifying the question that you want to answer" (Fry, 2008). The posters were created also talking in account i) students' educational needs ("reducing Irrelevant data, reducing "noise" (Steele & Iliinsky, 2010)), ii) the teaching plan context (educational objective, ICT, IBSE, outdoor activities, etc.) and c) interaction (the seven stages of creating an information visualization: acquire, parse, filter, mine, represent, refine and *interact* (Fry, 2008). The posters are available in Greek and in English http://4myfiles.wordpress.com/.

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Table 6: UDL principles (posters)

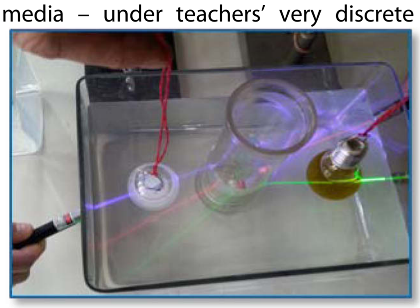
UDL Principle I: Information/Instruction offered in different ways
1st Guideline: Relevant information is available on the learning objectives and outcomes • in advance • at any time • temporarily ***How this guideline was implemented:*** posters as visual aids,& advance organisers are used ***2nd Guideline: Information can be assimilated in various ways*** • visual ***How this guideline was implemented:*** posters combining images, text, mathematics and sketches ***3rd Guideline: The understanding/comprehending of information is supported by providing various options*** • mind mapping • illustrations • gamification ***How this guideline was implemented:*** comprehension can be supported with the visual aids
UDL Principle II: Allow the learners to express what they know in different ways
4th Guideline: Learner can actively work with the learning materials in different ways • individual work • group work • discussion ***How this guideline was implemented:*** the visual aids can be used in activities that students implement either working indivindually or in small groups, they are a means for promoting discussions/intrigue open inquiry & facilitate the process ***5th Guideline: Learners can show the results of work as ...*** ***How this guideline was implemented:*** learners can decide whether they would like to be evaluated producing relevant materials (visual) or not ***6th Guideline: There are different forms of support provided such as ...*** • face-to-face mentoring • online mentoring • feedback on demand • formative (self) assessment **How this guideline was implemented:** these visual aids are available all the time supporting learners (proximal zone of development)
UDL Principle III: Learners are engaged and motivated in different ways
7th Guideline: Different known interests and motivators are addressed such as ... • authentic tasks • choice in context How this guideline was implemented: visual aids can create an interesting/calm learning atmosphere ***8th Guideline: Interests and goal attainment as well as resilience are stimulates actively by ...*** • practical relevance ***How this guideline was implemented:*** visual aids can clarify learning goals, supporting students' perception, helps them stay engaged in learning activities ***9th Guideline: There are opportunities for self-regulation provided ...*** • creative freedom • organizational flexibility ***this guideline was implemented:*** visual aids can enhance understanding, facilitate conceptualisation thus keeping students engaged in learning, they can promote self-reflection

ISBN 978-615-5511-06-6

Lasers & Bubbles

The educational activities regarding Lasers & Bubbles are shortly presented in Table 7 along with the UDL principles application as documented on the UDLnet inventory.

Table 7: The Lasers & Bubbles activities & the UDL principles

"Phase"	**Activities**	**UDL principles**
Pre-activities	We listed the core scientific concepts connecting with the Big Ideas of Science (http://www.golabz.eu/big-ideas) and we emphasized and on "*how light travels*" and "*is the same amount of energy 'entering' and 'exiting'?*" Staying on IWB we explored the "atom ≈ river analogy". We summed up with one of the following educational objects on diffraction from photodentro.edu.gr or PhET and the analogy with Takeshi's Castle Visiting Serres' LCS (https://youtu.be/ScpJSlUmA9s), we engaged our students to a plethora of introductory activities on lasers, total reflection, fibre optics, Morse code and bending light with sugar!	***UDL Principle I*** **1st Guideline - How this guideline was implemented**: visual aids, posters, artifacts ***2nd Guideline:*** **3rd Guideline: - How this guideline was implemented:** students have the opportunity to experiment ***UDL Principle II:*** ***4th Guideline: - How this guideline was implemented:*** students can work individually or in small groups ***5th Guideline - How this guideline was implemented:*** students have the flexibility to demonstrate the outcomes of the learning process in a variety of ways **6th Guideline - How this guideline was implemented:** the role of the teacher is centred around students' needs ***UDL Principle III*** ***7th Guideline- How this guideline was implemented:*** the active involvement of students makes them motivated ***8th Guideline -How this guideline was implemented:*** students have the opportunity to run hands on experiments themselves using low cost materials ***9th Guideline - How this guideline was implemented:*** students metacognition is supported with the use of specific questions (self-reflection, learn through trial & error) this is supported with use of the inquiry method (IBSE), pre-activities, activities in the lab (with use of real artifacts), experimentation, post-activities (support of metacognition, transfer of knowledge)
Main activity	The objective was to explore, describe, inquiry and explain light's behaviour passing through different media – under teachers' very discrete guidance. 	
Post-activity	At the end, we engage students into some very interesting activities: & videos, eye-doctor trick. We use red-cyan 3D vision to see some, easy to find in the web, images and also videos (https://youtu.be/X7RF7NvSu6A) so to raise the mechanism of human site.	
Discussion Conclusion(s) Extend	Back at the classroom each student presents his conclusions and final outcomes of project we discussed. After summarising, extension along with connection with everyday life follows.	

Conclusion and further work

It has proven far easier to help the various stakeholders understand the potential of UDL than it has been to implement UDL on a large scale. UDL requires collaborative planning amongst teachers with different curriculum knowledge and skills – especially in a "more open future" (Price, 2015). The methodological approach of UDLnet has been presented. UDLnet is in the process of collecting practices of universal design for learning with focus groups where stakeholders and experts might attend and contribute and we hope that the recommended approach will contribute towards creating and sharing inclusive open educational resources. An implementation/training period will follow, as well as annual reports documenting the findings. Further work remains the population of the UDLnet repository with such practices, their documentation according with the UDL Guidelines and Checkpoints (CAST, 2015) and the support of pilot implementation in schools all around Europe with the support of the respective educational community of practice/network.

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Acknowledgement

This research has been undertaken under the project UDLnet: Universal Design for Learning: A Framework for Addressing Learner Variability and Open Discovery Space Projects funded with support from the EC.

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

APPS VERSUS DEMONSTRATION EXPERIMENTS – IMPROVEMENT OF QUALITY OF PHYSICS TEACHING IN SECONDARY EDUCATION BY THE USE OF TABLETS

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Abstract

This paper outlines the possibilities for improving the quality in physics teaching by the use of tablets. With two project classes of the BG/BRG Schwechat the author carried out investigations to find out if apps with the feature of displaying results of measurements, with interactive simulations and with augmented reality content support pupils to achieve their learning skills. The instant read out and visual presentation of collected data makes the tablet extremely useful for physics teaching. Augmented reality inside and outside the classroom is not science- fiction any more.

During the evaluation teachers emphasized the importance of the community "iPads@BG/BRG Schwechat" launched at the Open Discovery Space Portal. Open Discovery Space is funded by the European Commission and is the result of collaboration between 51 organizations from 23 countries. The aim is to provide a socially-powered, multilingual, open learning infrastructure to boost the adaptation of e–learning resources in Europe.

Introduction

Over the last few decades life is hardly conceivable without digital devices and online tools. Desktop PCs, tablets and smartphones are important components of our everyday life. New digital developments arise and influence our everyday life. Nowadays, above all, young people can hardly live without internet, mobile phone or computer. The digital world, which is an important component of the social life of many youngsters, wins a bigger and bigger meaning in schools during the last years.

At many schools the use of online learning tools and platforms spreads more and more and during the last years there were initiatives over and over again to make the digital work in the classrooms the standard, as in [1].

In Austria the equipment with desktop PCs in public schools in secondary education has become a standard in the last years, more than 200 schools are participating in the so called eLSA project which has a focus in e-learning in everyday school life. But only 10 schools of the so called eLSA advanced network have experiences with the use of tablets, which are only 1.4% of all public schools in secondary education and 5% of all eLSA schools. In comparison with the use of smartphones and tablets of youths the author is of the opinion that schools should be more active in the implementation of mobile devices in the teaching process.

In 2013, the youths' personal equipment with computer or laptop has stabilized at a high level. 87% of internet users state they were logged into the internet through the computer or laptop; 73% used their mobile phone or smartphone to go online – this rate has tripled over the past three years, as in [4].

However, during the last years the use of mobile devices like tablets and smartphones for learning and teaching in schools remained far behind the use of these digital devices in the private life of youths. Tablet computers significantly reduce the sales of desktop computers and the question rises whether mobile devices using apps have the potential to improve the possibilities of e-learning or even displace desktop PCs in secondary school teaching.

The results of the "JIM – study 2013" – an investigation about the media usage of twelve- to nineteen-years-olds in Germany – show that the amount of the children who use a smartphone has reached 81% and that 15% of teenagers own tablets, as in [4]. In order to evaluate the situation in the urban East of Austria, the author of this paper carried out an anonymous online survey with 123 pupils aged between 12 and 18 at the BG/BRG Schwechat, a public school of secondary education in March 2014. 100% of the pupils stated, that they own a smartphone with access to the internet and the possibility to install apps. 64% of the pupils answered the question, if in their household is a tablet with yes. Asked if they use their smartphones also for learning purposes 12% answered with very often, 60% said often, 25% seldomly and only 2% answered never.

These results suggest, that there exists an enormous potential for teachers if these mobile devices could be used for education purposes in teaching concepts. In this work it will be discussed which kind of apps have the potential to improve the quality of physics teaching and in secondary education.

This paper is organized as follows: in Section 2 the research questions are described, chapter 3 describes the sample of pupils and teachers and the didactic approach. In chapter 4 the author presents the results of the investigations, chapter 5 presents the conclusion.

Research Questions

There is a huge emphasis on competence- based learning in teaching natural science. In order to improve these concepts the competence model sets not only standards in the field of acquiring knowledge but also in the field of acquiring learning objectives such as organizing knowledge, gaining insight, drawing conclusions and designing, as in [2].

The implementation of interactive graphs and digital animations makes it easier for students to understand complex processes in natural science, as in [3]. This leads to the assumption that apps with the feature of displaying results of measurements, with interactive simulations and with augmented reality content support pupils to achieve learning objectives.

ISBN 978-615-5511-06-6

Which kinds of apps can be used in the framework of competence based teaching and satisfy the requirements of a modern school with a focus in e-learning?

These issues can be broken down to three research questions:

1. Is it possible to substitute demonstration experiments carried out by teachers teaching Physics by apps carried out by students on tablets without losing quality of teaching?
2. Are apps with augmented reality features suitable to improve the motivation of students to deal with physics?
3. Are tablets a didactically more suited approach to competence-based teaching Physics than desktop PCs in a computer lab?

Research Methodology

The BG/BRG Schwechat, where the investigation took place, is a public school with about 1000 students aged 10 to 18 years, employing about 90 teachers. For several years now, the focus has been on eLearning, using 3 computer rooms with a total of over 90 PCs. In order to facilitate e-learning not only in computer labs but also in all 42 classrooms, a mobile solution with 30 iPads stored in a cart was implemented. This mobile e-learning unit is available for all teachers as long as they pre-register via an online reservation system. Supporting this concept a projector was installed in every classroom and full Wi-Fi coverage was set up in all parts of the school building.

The teaching methodology of the e-learning sequences in physics was developed in cooperation with the committee for "new graduation standards for Physics" and meets the requests of the competency model for physics.

For this study the author developed lesson plans and activities implementing apps. These documents and working instructions for the use of the apps are published at the Open Discovery Space platform available in the community "iPads@BG/BRG Schwechat".

To answer the research questions mentioned above, the following three stepped approach was chosen:

1. The author taught physics in a 3rd class with 23 pupils aged 12 and 13 and in a 7th class with 26 pupils aged 15 and 16 using tablets and apps instead of demonstration experiments. As an indicator for the teaching and learning quality the students' grades at the end of the semester were used.
2. At the end of the semester students were asked about their opinion about their learning experiences with augmented reality apps using the anonymous feedback tool integrated in the learning platform "Moodle".
3. During a workshop with teachers the author presented a selection of apps to a sample of the science teachers who had average experience in e-learning. The teachers where

Transforming Schools into Innovative Learning Organisations
EDEN Open Classroom Conference Proceedings, 2015, Athens
ISBN 978-615-5511-06-6

asked to register in the "iPad@BG/BRG Schwechat" community and to share their experiences.

E-learning with apps instead of demonstrations experiments

Demonstrations experiments are an essential tool in physics teaching in order to demonstrate laws of physics – this has been communicated during teacher training in physics for many years. However, this concept often leads to situations in which one person is presenting in front of a relatively large number of students who have a passive role in this concept. They have to sit back and watch an setup which is in many cases too small to provide all students with clear view on all the important parts. In many cases the crucial elements are pointers of some measuring tools, which are moving across a scale.

In order to promote an active learning environment where students are allowed perform experiments themselves the author used tablets and apps. It is not only possible to simulate some demonstration experiments by the use of tablets without the drawbacks discussed above but also to improve the thirst for knowledge of students. The author chose the following 3 apps covering the topics of the curricula of the classes mentioned above: iCircuit, ProScope Mobile and SparkVue. Best practice examples of educational scenarios using these apps are described below.

The app "iCircuit" (available for iOS and Android) is an electronic circuit simulator, which allows students to design electric circuits using predefined circuit elements just like working with real circuit components. Using the app students are able to use a digital multi-meter for measuring voltages and currents in their circuits. A great feature is the built-in digital oscilloscope, which displays how values change over time. As the app uses the cloud storage, students can easily share their circuits in order to discuss their results with peers.

In contrast to classical experimental designs in the physics lab, where students often only see moving pointers in analogue measuring instruments, the use of the app "iCircuit" motivates students to carry out in-depth analysis. The availability of the app for the students' own mobile devices increases this effect.

Another innovative scenario is the usage of the "ProScope Mobile", a wireless handheld digital microscope. The "ProScope Mobile" app establishes a static IP WiFi network and allows a connection with up to 254 iOS devices. Using this app, students can simultaneously view live images and capture stills on their mobile devices while a teacher or another student operates the microscope. "ProScope Mobile" in scientific teaching proves an essential advantage of tablets in comparison to a classical setup using a microscope and printed worksheets. The operator of the device ensures that all students actually see the intended structure, students can save images of the structure on their device, which offers various didactic possibilities (e.g. naming structures).

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Great opportunities for enhancing physics teaching by the use of tablets offer the app "SparkVue" (available for iOS and Android devices): "SparkVue" enables real-time data collection with a mobile device. The app collects data from the internal acceleration sensors of the mobile device or from an external sensor connected with an "AirLink2" Bluetooth interface to the device. Students are able to measure data in real time from more than 70 sensors, students of the two project classes used sensors for air pressure, temperature, infrared, UV radiation and acceleration. The author implemented some learning scenarios with iPads used as mobile laboratories, for example students easily investigated the dependence of the air pressure of the altitude by moving around with the iPad and the sensor. In addition to collecting data on tablets, "SPARKvue" supports live sharing of sensor data with any other smartphone, tablet, Mac or Windows PC. Students are enabled to capture the shared data from a remote session on their own device for further analysis. This feature provides various possibilities to enrich collaborative learning.

Apps with augmented reality features

The author used the following 3 apps in order to investigate the possibilities of apps with augmented reality features: "Video Physics", "SkySafari" and "Redshift".

In lessons about mechanics the use of camera of the tablet allows recording and analysis of motion. This improves the pupils' understanding of the relationships between time, velocity and acceleration in different types of motion. The activity starts with capturing video clips of the moving object with the camera of the mobile device. As next step students have to open the app "Video Physics" (available for iOS and Android) and to import the video from the camera roll of the mobile device. Now the position of the moving object has to be marked frame by frame by tapping on the object. "Video Physics" then displays the path of the object and draws graphs of the position and velocity of the object. The graphs are provided as y versus x as well as the position and velocity as a function of time. Students using their smartphones are motivated to take short video clips of moving objects in their leisure and bring them into Physics lessons for analysis - so teaching mechanics is connected directly with experiences of the pupils.

Teaching astronomy apps with augmented reality features provide great possibilities to improve the teaching quality. There is a wide range of astronomical apps available in app stores, the author prefers the astronomical applications "SkySafari" and "Redshift" (both available for iOS and Android). These apps access the built-in GPS and magnetic sensors of the mobile device and provide in combination with the acceleration sensor a very impressive and interactive exploration of the sky. Celestial objects are displayed depending on the recent date, location and the direction of view, so that the orientation in the sky is very easy. The variation of date and location allows an analysis of celestial events like solar eclipses of the past or in the future. Tapping at an object gives detailed information, zooming to an astronomical object provides pictures of the object in high resolution. As additional tool "SkySafari" offers the possibility to control the movement of a telescope – the user has only to choose an

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astronomical object on the tablet and the "GoTo" command moves the telescope to the selected object. The app "Redshift" (available for iOS devices) leads students using the function "Scan the Sky" to a certain object in the sky: the app guides the user displaying the direction where the tablet has to be moved. An impressive feature is the possibility to turn on the camera and to move around the real sky with virtual information displayed from the app. With the observatory option students can move from the own location to any other location of the earth and compare constellations of stars and planets.

The author used these features of the astronomical apps carrying out an outdoor scenario with pupils of the 3rd grade (12, 13 years old pupils): after sunset the group met on a little hill near the school: the teacher directed an "Meade" telescope with an iPad and the app "SkySafari" to objects in the sky, students waiting for the observation used iPads and scanned the sky in order to collect information about visible objects or constellations.

Results

The students of the two participating classes used the apps mentioned above to a high extent to cover the topics of the curriculum scheduled in the 2nd semester. Long term observation of the pupils' level of commitment gave significant result: pupils participated very motivated in solving their tasks with iPads, the usage of these digitals devices and apps caused a higher motivation than teaching with classical demonstration experiments. Pupils had no difficulties to control apps with swipe gestures well known on their smartphones, a short instruction was needed to connect the tablets with Bluetooth to the sensors.

E-learning with apps instead of demonstrations experiments – results

An adequate way of measuring the extent to which the students reached their learning goals after the intensive use of iPads was comparing their grades in Physics at the end of the semester with similar classes where no iPads were used. For better understanding of the following results in the Austrian grading system the best grade is "Sehr gut, 1" (very good), followed by "Gut, 2" (good), "Befriedigend, 3" (satisfying), "Genügend, 4" (sufficient) and "Nicht genügend, 5" (not sufficient).

Among the younger students, 34.8% were assessed with "Sehr gut", 21.8% with "Gut" and 30.4% with "Befriedigend"; only 13% got "Genügend", nobody was graded "Nicht genügend", a distribution with a mean of 2.2 and a standard deviation of 1.1. Among the older students the result was as follows: 46.2% of the students obtained "Sehr Gut", 30.8% "Gut" and 23% "Befriedigend", nobody was assessed with "Genügend" or "Nicht genügend", which gave a mean of 1.8 and a standard deviation of 0.8. These results are visualized in the following chart comparing the grades of Physics of the two project classes.

ISBN 978-615-5511-06-6

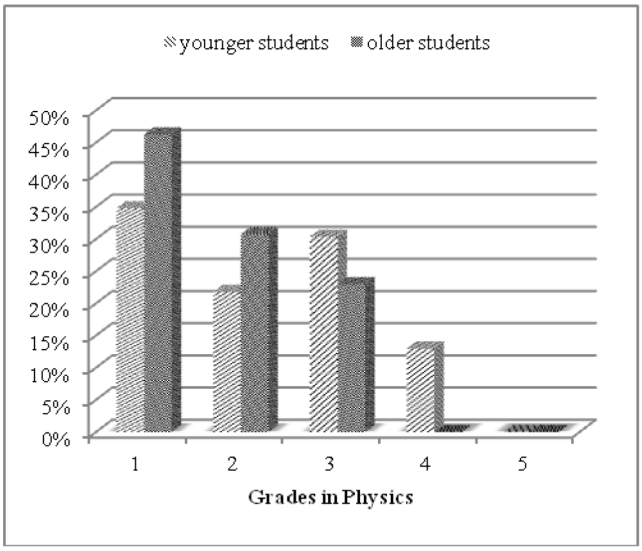

Figure 1.

Comparing their grades to former classes who did not use iPads or e-learning in any way, the grades of the iPad classes were significant better.

The major influence on the grades is the performance of the student, but there are a variety of other influences, as in [5]. The argumentation, that the usage of iPads improves the grades in physics cannot be proved clearly by these results, but it seems evident, that the use of iPads does not influence the students' grades in a negative way. In the opinion of the author it is obvious that the usage of iPads causes a higher motivation and higher extent of educational activities of students during lessons.

Apps with augmented reality features – results

The feedback of the pupils regarding the apps offering augmented reality was collected with the anonymous feedback tool of Moodle. Pupils completed a questionnaire offering 5 categories for answering each question.

79% strongly agreed to the statement that their motivation to deal with physics was increased by the usage of the apps "VideoPhysics" and "SkySafari", only 10% negated this statement. 68% stated that they have better understanding in scientific laws by the use of this device, only 17% reported that they were confused by the moving display during turning around the iPad. The integration of video clips in physics lessons was valued almost by everybody as an important enrichment of the lessons.

Tablets versus desktop PCs – advantages and disadvantages of tablets from teachers perspective

As first result teachers emphasized the importance of a mobile device management software for the maintenance of tablets used as shared tablets in a school. The usage of such program ensures that students cannot install apps, which are not suitable for school education. Another feature of such software is the simple synchronization of the tablets: apps are stored on a PC

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or notebook and sent to all devices stored in the cart. This guarantees that all tablets have the same apps installed.

Teachers participating in the workshops agreed that tablets show their advantages in the context of blended learning sequences: there is no need to move from the classroom to the PC laboratory, the devices come with the iPad cart in the classroom, are instantly ready to use and allow pure haptic interaction with the content. Tablets appeal with their simple interface and very stable operating system. These also encourage teachers with few digital competences to implement e-learning during their lessons.

During the implementation the question occurred how to upload files from an iPad to the learning platform “Moodle”: The easiest way to achieve an upload to “Moodle” is to upload a screenshot of the document from the photo album of the iPad. The use of the photo album as upload folder encourages the use of iPads in blended learning lessons: a worksheet or sketch with was done with pencil and paper is captured by the camera of the mobile device and uploaded to “moodle” for the assessment by the teacher. These improve the usability of assessments: papers don’t have to be collected and distributed, assessment and comments of the teacher about the students’ work are available online. A simple way to share files from tablets is the upload to cloud services like Dropbox, Google drive and so on, because most of the apps have a direct access to cloud storages.

Teacher as well as students reported the so called “AirPlay” mirroring of iOS devices as great feature of iPads: “AirPlay” mirroring brings the content of the iPad directly to a projector which is connected with an Apple TV. This feature is also available if a PC is connected with the projector: with the software “AirServer” installed on the PC an iPad user can wirelessly beam the display of the iPad to the projector. “AirServer” supports multiple connections which enables the comparison of displays of some students. This encourages teachers to design activities giving students the ability to share ideas or to collaborate with classmates.

As disadvantage of the use of tablets in the classroom the lack of the support of Java and Flash was mentioned. This fact prevents the display of content of web pages based on Java or Flash. The excellent interactive simulations from the University Colorado Boulder available at https://phet.colorado.edu cannot be used with tablets. But the University of Colorado Boulder announces as “future of phet” the conversion of the Java based simulations to HTML5 simulations, which makes them available for tablets running with most of the common operating systems.

A further validation of the concept "teaching physics by the use of tablets” was carried out at two levels:

- First, teachers participating in workshops “iPads in scientific teaching” of the author had the opportunity to express their views on the usage of apps in physics teaching.
- Secondly, the concept was discussed in the course of advanced education for physics teachers at the University of Vienna. Every teacher participating in the workshops saw

great potential in the use of tablets in the classroom. The high mobility of the tablets and their potential in blended learning sequences in the classroom without moving the whole class to the computer lab were highlighted.

Conclusion

The project proves that learning and teaching with tablets and apps in physics teaching helps and support pupils in understanding complicated scientific concepts and in reaching their learning goals.

The use of modern tablets and smartphones for visualising purposes and as measuring devices brings significant benefits for achieving learning goals because they seem to be easier to handle, which allows students to concentrate on their tasks. Moreover, the easy availability of scientific content on tablets, which are excessively used by students in private, motivates students to occupy themselves with scientific topics outside the school environment.

This conclusion highlights the need of digital resources for teaching purposes and educational scenarios for the usage of tablets. The Open Discovery Space portal (http://portal.opendiscoveryspace.eu) offers possibilities to create communities to share and discuss educational content all over Europe. 8902 registered teachers cooperating in 897 communities (in August 2015) prove the great acceptance of this platform.

The community "iPads@BG/BRGSchwechat" hosted at the Open Discovery Space portal has become in Austria a well-known repository for science teaching with iPads, the community "Teaching & Learning with iPads in competence-based Science Teaching" offers content and educational scenarios in English.

In conclusion, tablets and smartphones will have an important role in future teaching. Young people are using to a high level visual, digital content at mobile devices in their private life, modern teaching and learning should use these new technologies und adapt them for educational purposes. The author is highly confident that due to the results described above tablets will find their way into science teaching. School authorities should start to make some efforts in integrating mobile devices in didactic designs instead of developing concepts how to forbid the use of smartphones in schools.

ISBN 978-615-5511-06-6

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ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

FLIPPED CLASSROOM TEACHING MODEL TEMPLATES FOR STEM EDUCATION

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Introduction

Science, Technology, Engineering and Mathematics (STEM) education has been recognized as a top priority for school education worldwide [1]. The focal points of STEM education posit the standpoint that student-centred teaching approaches should be exploited for cultivating (among others) students' critical thinking, inquiry and problem solving competences, reasoning and creativity abilities, as well as exploiting these competences in the context of addressing real-world problems and phenomena [2]. In addition, innovative blended-teaching models, such as the Flipped Classroom (FC) model, are being increasingly deployed to enhance student-centred teaching approaches in order to optimize the use of face-to-face teaching time for cultivating the aforementioned student competences ([3], [4]).

In this context, and considering the novelty of the FC model, teachers (especially novices) could benefit from having access to teaching model templates for supporting the design of FC-enhanced STEM lesson and educational scenarios plans. More specifically, towards facilitating STEM teachers, such blended-teaching templates should i) provide a structured, "generic" framework for authoring teaching, learning and assessment activities within the specific phases of "STEM-appropriate" teaching models and ii) incorporate the standpoints of the FC Model in terms teaching, learning and assessment activities distribution between the teacher-led face-to-face classroom and/or lab-based sessions and the student-led "homework" sessions. Under this light, the contribution of this paper is the design of two Flipped Classroom templates, based on widely used teaching models in the context of STEM education, namely the Inquiry-based teaching model and the Problem-based teaching model.

The remainder of the paper is as follows. The "Background" section presents the background of this work, namely the FC Model and argues towards its capacity to support STEM Education. The "Flipped Classroom Teaching Model Templates" section describes two widely used teaching models for supporting STEM Education (i.e., the Inquiry- and Problem-based teaching models) and presents their proposed FC-enhanced templates. Finally, the paper discusses potential future work directions.

Background

Flipped Classroom Model

The FC model is an emerging, blended teaching model which mainly argues towards improving the student-centred exploitation of face-to-face classroom and/or lab time [5]. More specifically, it posits the key notion that teacher-supported face-to-face sessions should not be spend on delivering lectures, but rather on engaging students in more teacher-supported "hands-on" (possibly collaborative) activities promoting active engagement, scaffolding and feedback [6]. This standpoint is based on the argument that teacher-supported face-to-face sessions can provide students with unique learning experiences through the direct access to both their classmates (for engaging in collaborative activities) as well as to feedback and scaffolding by their teacher, which are not fully supported by traditional lectures. On the contrary, lecture delivery can be easily substituted by appropriately designed/selected educational resources (e.g., educational videos) towards introducing basic knowledge to the students in an autonomous manner, also incorporating self-assessment through simple quizzes and tests [6].

Based on its aforementioned characteristics, the FC model has been recently proposed and exploited within the context of STEM Education, towards providing an additional level of addressing the emerging needs for promoting students' active participation and inquiry (e.g., [7], [8], [9]).

Flipped Classroom Model for STEM Education

Recently, the FC Model has received noticeable attention and exploitation in the STEM domain [3]. Several studies have been conducted, which share a level of common findings towards validating the FC model's capacity to enhance existing teaching practice within the STEM domain. More specifically, the FC has been repeatedly reported to offer added value in terms of improving student attitudes towards STEM ([7], [10]), enhancing their motivation and active engagement in the learning process [4] as well as supporting attainment of learning objectives related to both subject domain knowledge as well as critical thinking, problem solving and inquiry skills ([4], [7], [10]).

Therefore, it is becoming increasingly recognized that the FC model can significantly enhance existing student-centred teaching models (such as the Inquiry- and Problem-based models) towards realizing the emerging global STEM education needs for active student inquiry and engagement, as well as cultivating the students' subject matter knowledge. Under this light, this paper aims to facilitate STEM teachers (especially novices) for designing their lessons and/or educational scenarios by proposing "generic" teaching model templates based on commonly accepted STEM-appropriate teaching models, further enhanced with the FC model. The proposed Flipped Classroom templates for two widely used teaching models in the context of STEM education, namely the Inquiry-based Model and the Problem-based Model are described in the following section.

Flipped Classroom Teaching Model Templates

Inquiry-based Flipped Classroom Teaching Model Template

The Inquiry-based Model (IBM) is a widely accepted teaching model for supporting STEM education due to its capacity to engage students in creating their own reasoning on real-life problems and phenomena [11]. Moreover, in the context of STEM, several studies have shown that IBM can have a significant positive influence (among others) on the students' learning achievements and understanding [12], level of motivation [13] and engagement [14].

The structural representation of the IBM used in this paper, which is an adaptation of the models proposed by [15] and [16], is presented as follows, divided in its constituent Phases:

- **Phase 1: Orienting / Asking Questions.** Phase 1 involves the presentation of the problem to be investigated and aims to provoke curiosity.
- **Phase 2: Hypothesis Generation & Design.** Phase 2 involves the formulation of initial hypotheses from the students based on their own reasoning and current understanding of the problem.
- **Phase 3: Analysis & Interpretation.** Phase 3 involves the analysis and organization of the research/experimentation processes and the related tools/resources that will facilitate them. These can be discovered by the students or be provided by the teacher.
- **Phase 4: Planning and Investigation.** Phase 4 engages students in experimentations exploiting the processes and tools/resources outlined in Phase 3.
- **Phase 5: Conclusion and Evaluation.** Phase 5 includes reflective analysis of the students' initial hypotheses based on the experimentation results and formulation of a final common solution.

Building on the aforementioned structural phases of the IBM, Table 1 presents the proposed FC-enhanced Inquiry-based teaching model template. The proposed FC-enhanced IBM template incorporates the use of a Course Management System (CMS) for orchestrating the teaching, learning and assessment activities beyond the physical learning space of the school classroom and/or lab.

ISBN 978-615-5511-06-6

Table 4: Flipped Classroom Inquiry-based Model Template

IBM Phase	"Home-based" Activities – CMS Based	Face-to-face "Classroom-based" Activities
1. Orienting / Asking Questions	**Teacher:** [Presents] using digital material (e.g., [**video**]) of the problem of the educational scenario to be researched. [Presents] the educational objectives to be achieved and the [**Assignment(s)**] to be performed in Phase 4. [Presents] the activities to be performed in the next f2f session. **Students**: [Study] the introductory digital material uploaded [Engage in Discussion] / [Posts Questions] on the [**Forum**] to be discussed in the next f2f session	**Teacher:** [Orchestrates Discussion] [**verbally**] on the problem to be researched [Performs] [**diagnostic assessment**] quiz test. These [**diagnostic assessment]** data will be utilized for scaffolding students with significant gaps in existing competences **Students:** [Engage in Discussion] **[verbally]** based on their prior home study of the digital material [Engage in task], i.e., the [**diagnostic assessment**] quiz.
2. Hypothesis Generation & Design	**Teacher:** [Presents] instructions to students to utilize [**concept map tool]** or [**Wiki]** tools to formulate *initial* hypotheses to answer the set problem. [Monitors] student participation through [**CMS tracking data]** (e.g., resource views, page access traces, forum posts). [Provides Feedback] when appropriate (e.g., **[Forum]**). [Presents] the activities to be performed in the next f2f session [Assigns Task], i.e., to formulate *initial* hypotheses to answer the set problem (The task will continue in the next f2f session) **Students**: [Engage in task], i.e., the formulation of *initial* hypotheses for the set problem (following the instructions) utilizing the given Tools	**Teacher:** [Orchestrates Discussion] [**verbally**] on the problem to be researched [Presents] information that might have escaped the students' notice. [Provides Feedback] when needed based on the [**CMS tracking data]** and observation. **Students:** [Engage in task], i.e., the finalization of *initial hypotheses* for the set problem (following the instructions) utilizing the given Tools . [Engage in Discussion] **[verbally]**
3. Analysis & Interpretation	**Teacher:** [Shares Resources], i.e., digital research material (e.g., references, tools) related to the experimentation process of Phase 4. [***Optionally***] [Formulates student groups], considering **diagnostic assessment**] quiz results and [**CMS tracking data].** [Monitors] student participation through [**CMS tracking data].** [Provides Feedback] when appropriate (e.g., **[Forum]**). [Presents] the activities to be performed in the next f2f session. **Students:** [Study] the digital research material uploaded [Engage in Discussion] / [Posts Questions] on the [**Forum**] to be discussed in the next f2f session	**Teacher:** [Orchestrates Discussion] [**verbally**] on the digital research material and the experimentation process of Phase 4. [Provides Feedback] based on observation, Phase 1 [**diagnostic quiz assessment]** and [**CMS tracking data]**). [Assigns Task], i.e. to locate further digital research material. **Students:** [Engage in task] of locating further digital research material. [Engage in Discussion] [**verbally**] towards clear understanding of the Phase 4 experimentation process
4. Planning & Investigation	**Teacher:** [Shares Resources], i.e., digital resources for (a) explaining and (b) facilitating the experimentation process (e.g., [**virtual /remote lab]**). [Monitors] student participation through [**CMS tracking data].** [Provides Feedback] when appropriate towards ensuring all students' understanding on the Phase 4 experimentation process. **([Forum]).** [Presents] the activities of the next f2f session. **Students:** [Study] the digital research material uploaded [Engage in Discussion] / [Posts Questions] on the [**Forum**] to be discussed in the next f2f session	**Teacher:** [Assigns Task], i.e. to perform experimentation process using the given digital resources [Provides Feedback] [**verbally]** during the experimentation process based on observation. **Students**: [Engage in task], i.e., in the experimentation process using the provided digital resources and/or **[physical tools]** [Collect data] and [Record findings] from experiments towards answering the set problem [Engage in task], i.e., formulation of the Assignment deliverable based on the experiment findings.
5. Conclusion & Evaluation	**Teacher:** [Monitors] student participation through [**CMS tracking data].** [Provides Feedback] when appropriate (e.g., **[Forum]**). [Shares Resources], i.e., peer-assessment rubric to be used for peer-assessment activity in next f2f session [Assesses] the students' [**digital deliverables]** and provides [**summative assessment]** feedback individually/in groups. [Presents] the activities of the next f2f session. **Students**: [Submit deliverable], i.e., the final Assignment deliverables [Reflect] on their final Assignment deliverables considering their *initial* hypotheses (Phase 2) and the [**summative assessment]** feedback.	**Teacher:** [Assigns Task], i.e. to present their Assignment deliverables towards peer-assessment. [Provides Feedback] based on (a) students' **[Assignment]** deliverables, (b) [**CMS tracking data**] and (c) their presentations. **Students**: [Engage in task], i.e., presentation / peer-assessment of their Assignment deliverables. [Engage in Discussion] **[verbally]** towards receiving feedback based on the three aspects mentioned above and formulating a shared understanding of the experiment-based solution to the problem.

As the Table 1 depicts, the proposed IBM template presents a blueprint for STEM teachers to design their lessons and/or educational scenarios, by explicitly mapping the IBM phases to different educational activity types and also distributing them between the teacher-supported face-to-face sessions and the student-led "homework" sessions. As aforementioned, the driving principle behind the proposed template is to re-arrange the teaching, learning and assessment activities towards exploiting the face-to-face classroom and/or lab based sessions for student-centred engaging educational activities, while populating the student-led "homework" sessions with activities mainly related to self-regulated studying of educational content.

ISBN 978-615-5511-06-6

In a similar vein, the following section presents the proposed FC-enhanced template for another widely exploited teaching model in the context of STEM, namely the Problem-based teaching model (PBM).

Problem-based Flipped Classroom Teaching Model Template

The PBM is a goal-driven flow of activities aimed at exploiting inquiry processes for solving ill-defined problems [17]. Therefore, it includes active student engagement towards modelling, analysing and ultimately formulating individual solutions for a given problem which has no clear pre-existing solution or solving strategy (i.e., it is ill-defined) [18]. In the context of STEM, PBM has been repeatedly exploited in order to enhance the learning process in terms of (a) cultivating students' (collaborative) problem-solving skills ([19], [20]), (b) enhancing their understanding related to STEM [21], as well as (c) increasing their level of motivation and engagement [20]. Therefore, similarly to the IBM, PBM is a widely used model for designing STEM lessons and/or educational scenarios.

The structural representation of the PBM used in this paper (based on [22]), is presented as follows divided in its constituent Phases:

- **Phase 1: Problem Identification.** Phase 1 involves the identification of the ill-defined problem to be solved.
- **Phase 2: Problem Representation.** Phase 2 involves the specific representation and modelling of the identified ill-defined problem (e.g., method of de-composition to its constituent parts).
- **Phase 3: Problem Solving Strategy Formulation / Selection.** Phase 3 is related to the selection or formulation of the optimal strategy for solving the identified ill-defined problem.
- **Phase 4: Problem Solving Strategy Implementation.** Phase 4 engages students in the process of implementing the selected strategy for solving the identified ill-defined problem.
- **Phase 5: Evaluation.** Phase 5 includes reflective analysis of the students' solutions to the identified ill-defined problem, based on the teacher's and peers' feedback.

Building on the aforementioned structural phases of the PBM, Table 2 presents the proposed FC-enhanced Problem-based teaching model template. Similarly to the IBM, the proposed FC-enhanced PBM template incorporates the use of a CMS for orchestrating the teaching, learning and assessment activities beyond the physical learning space of the school classroom and/or lab.

ISBN 978-615-5511-06-6

Table 5: Flipped Classroom Problem-based Model Template

PBM Phase	"Home-based" Activities – LMS Based	Face-to-face "Classroom-based" Activities
1. Problem Identification	**Teacher:** [Presents] the problem of the educational scenario to be solved using digital material (e.g., [**video**]), [Presents] the educational objectives to be achieved and provides the [**Assignment(s)**] to be performed. [Presents] the activities to be performed in the next f2f session. **Students:** [Study] the introductory digital material uploaded [Engage in Discussion] / [Posts Questions] on the [**Forum**] to be discussed in the next f2f session	**Teacher:** [Orchestrates Discussion] [**verbally**] on the problem to be solved [Performs] [**diagnostic assessment**] quiz test. These [**diagnostic assessment]** data will be utilized for scaffolding students with significant gaps in existing competences **Students:** [Engage in Discussion] [**verbally]** based on their prior home study of the digital material [Engage] in the [**diagnostic assessment**] quiz.
2. Problem Representation	**Teacher:** [Shares Resources], i.e., digital support resources (e.g., tools and/or techniques) for modelling the problem. [Monitors] student participation through [**CMS tracking data].** [***Optionally***][Formulates student groups], considering [**diagnostic assessment**] quiz results and [**CMS tracking data].** [Provides Feedback] when appropriate (e.g., **[Forum]**). [Presents] the activities to be performed in the next f2f session **Students:** [Study] the digital support resources [Engage in Discussion] / [Posts Questions] on the [**Forum**] to be discussed in the next f2f session.	**Teacher:** [Orchestrates Discussion] [**verbally**] on the problem to be solved and the digital support resources. [Presents] information that might have escaped the students' notice. [Assigns Task], i.e., to engage in problem modelling. [Provides Feedback] when needed based on the [**CMS tracking data]** and observation. **Students:** [Engage in task], i.e., model the problem using the methods/techniques provided in the digital support resources [Engage in Discussion] **[verbally]**
3. Problem Solving Strategy Formulation / Selection	**Teacher:** [Shares Resources], i.e., digital support material (e.g., reports, tools) related to the candidate problem solving strategies. [Monitors] student participation through [**CMS tracking data].** [Provides Feedback] when appropriate (e.g., **[Forum]**). [Presents] the activities to be performed in the next f2f session. **Students:** [Study] the digital support material towards understanding the candidate problem solving strategies [Engages in Discussion] / [Posts Questions] on the [**Forum**]	**Teacher:** [Orchestrates discussion] [**verbally**] on the digital support material on the candidate problem solving strategies [Assigns Task], i.e., engages students to select/formulate the problem solving strategy to solve the problem. [Provides Feedback] when needed based on the [**CMS tracking data]** and observation. **Students:** [Engage in Discussion] [**verbally**] towards clear understanding of the candidate problem solving strategies [Engage in task] of selecting/formulating the problem solving strategy to solve the problem.
4. Problem Solving Strategy Implementation	**Teacher:** [Provides Feedback] when appropriate (e.g., **[Forum]**). [Presents] the activities to be performed in the next f2f session. **Students:** [Engages in Discussion] / [Posts Questions] on the [**Forum**] towards full comprehension of the selected problem solving strategy and the way it will be used for solving the problem.	**Teacher:** [Assigns Task], i.e. to engage in the problem solving strategy implementation. [Supports/Facilitates] students during the problem solving strategy implementation [Provides Feedback] **[verbally]** based on observation. **Students:** [Engage in task], i.e., in the problem solving strategy implementation. [Collect data] and [Record findings] based on their problem solving strategy implementation towards solving the problem
5. Evaluation	**Teacher:** [Monitors] student participation through [**CMS tracking data].** [Provides Feedback] when appropriate (e.g., **[Forum]**). [Shares Resources], i.e., peer-assessment rubric to be used for peer-assessment activity in next f2f session [Assesses] the students' [**digital deliverables]** and provides [**summative assessment]** feedback individually/in groups. [Presents] the activities of the next f2f session. **Students:** [Submit deliverable] i.e., the final Assignment deliverables. [Reflect] on their final Assignment deliverables considering the [**summative assessment]** feedback.	**Teacher:** [Assigns Task], i.e. to present their Assignment deliverables towards peer-assessment. [Provides Feedback] based on (a) students' **[Assignment]** deliverables, (b) [**CMS tracking data**] and (c) their presentations. **Students:** [Engage in task], i.e., in Presentations / peer-assessment of their Assignment deliverables. [Engage in Discussion] [**verbally**] towards receiving feedback based on the three aspects mentioned above and formulating a shared understanding of the solution to the problem.

As the Table 2 depicts, the proposed PBM template presents a blueprint for STEM teachers to design their lessons and/or educational scenarios. Similarly to the IBM template, the PBM phases have been populated with educational activity types aimed at supporting the focal point of each Phase. Furthermore, the teacher-supported face-to-face activities have been populated with educational activity types focusing at active engagement of the students in the core problem-solving processes of the PBM, i.e., the selection/formulation of the problem solving strategy to be exploited, the implementation of the selected strategy, as well as the presentation of their solutions to the problem. On the contrary, the student-led "home-based" educational activities mainly comprise familiarization with educational content and tools to be used in a consequent face-to-face session.

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Overall, by formulating a structured depiction of the PBM (and the IBM), the proposed FC-enhanced teaching model templates aim at providing STEM teachers with "generic" frameworks which can be further adapted and instantiated with specific educational activities and educational resources/tools towards meeting their own teaching and curriculum needs. Additionally, the incorporation of key standpoints of the FC model can provide useful guidelines to STEM teachers who are keen to embed it in their blended lessons and/or educational scenarios towards reaping its reported benefits.

Future Work

Future work could include the formulation of additional FC-enhanced teaching model templates focusing on other subject domains, such as the Social Studies or Language Learning courses. Furthermore, the proposed FC-enhanced teaching model templates could also be implemented within existing CMS (such as Moodle – https://moodle.org/ [Accessed 20 August 2015]) towards facilitating teachers to not only design but also to deliver their Flipped Classroom STEM lessons and/or educational scenarios. Finally, another strand of future work should focus on the evaluation of the proposed FC-enhanced teaching model templates from actual teachers in terms of the provided added value in the process of designing their FC STEM lessons and/or educational scenarios as well as, the formulation of different instances that capture the reflective real-life teaching practice in various school and/or curriculum settings, such as primary and secondary education or different STEM curricula in the various member states of European Union.

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Acknowledgement

The work presented in this paper has been partially funded by the European Commission in the context of the Go-Lab project (Grant Agreement no. 317601) under the Information and Communication Technologies (ICT) theme of the 7th Framework Programme for R&D (FP7). This document does not represent the opinion of the European Commission, and the European Commission is not responsible for any use that might be made of its content.

ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

CHARACTERIZING ONLINE LABS FOR SCHOOL STEM EDUCATION USING EDUCATIONAL METADATA

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Introduction

Science, Technology, Engineering and Mathematics (STEM) education is recognized as a top priority for school education worldwide, and, thus, a key challenge for technology-supported and technology-enabled school education innovations [1]. Developing scientific literacy in compulsory school education requires preparing students to be able to understand the nature and development of scientific knowledge, to generate and evaluate scientific evidence and explanations, and to participate productively in scientific practices and discourse [2].

Within this context, online labs constitute digital educational tools which can have a significant role in supporting STEM education [3]. In particular, online labs have been attributed with a higher level of effectiveness in increasing students' interest in STEM and their engagement in related learning activities compared to traditional laboratories [4], [5]. Thus, many educational institutions and scientific organizations have invested efforts for providing online access to science experiments via online labs [6]. This has led to a large number of online labs that are available for STEM teachers to select and use. However, existing online labs are scattered around the web without a commonly accepted method for characterizing them. This a hindering factor for STEM teachers to search and retrieve efficiently and effectively online labs for further usage into their day-to-day teaching activities. Thus, the aim of this paper is twofold: i) to collect a sample of online labs that are currently available online and characterize them with a common educational metadata schema and ii) to perform an analysis of the educational metadata of the collected online labs towards providing insights about their characteristics.

The remainder of the paper is as follows. Section "Background" presents the background of this work, namely the different types of online labs and their main characteristics, as well as the selected metadata schema that has been used for describing the collected sample of online labs. Section "Study Methodology", presents the methodology that was followed for collecting the sample of online labs and the metrics that were used for the metadata analysis. Section "Results: Analysis of Educational Metadata", presents the analysis of specific metadata elements for the collected online labs and it provides useful insights about their characteristics. Finally, section "Conclusions and Future Work" concludes the paper and presents potential future work.

Background

Types of Online Labs

Online labs can be divided in three main types, as follows:

- **Remote Labs:** these are physical laboratories that can be operated at a distance and they provide students with the opportunity to conduct real experiments and collect real data from a physical laboratory in a remote location. The main advantage of remote labs is that students are operating actual equipment and not simulations. This gives them a more realistic view of scientific work including difficulties and complications such as unexpected factors interfering with measurements, experimental inconsistencies and occupied equipment [7].
- **Virtual Labs:** constitute interactive environments for designing and conducting simulated experiments. More specifically, they can range from simple simulations of physical processes that allow students to manipulate few variables to accurate simulations of experimental processes complemented with functionalities to measure experimental errors. Thus they are able to simulate physical processes that may be hazardous or even dangerous to study in a real lab. The main advantage of virtual labs is that students usually need no experience to operate them, other than basic computer skills to manipulate virtual labs and they can test any parameters even, in some cases, those that would lead to damage of the physical equipment in a physical lab [8].
- **Data Set Analysis Tools:** data sets are outcomes of investigations with physical or virtual equipment. They often come with dedicated analysis and visualization tools that help to organize and interpret the dataset. The main advantage of data set analysis tools is that they can substitute real experiments and measurements when access to such experiments is time consuming or costly (e.g. students can directly access observations of the sun that have been taken over a period of 20 years and investigate the solar activity cycle) [9].

Metadata Schema for Characterizing Online Labs

In our previous work [10], a review of existing repositories of remote and virtual labs was performed in order to highlight the metadata schemas adopted by existing online labs repositories. Furthermore, we conducted a comparative analysis of the elements used by the metadata models of these repositories [11]. Based on this analysis, we developed our proposed metadata schema, which is depicted in Table 1.

Transforming Schools into Innovative Learning Organisations
EDEN Open Classroom Conference Proceedings, 2015, Athens
ISBN 978-615-5511-06-6

Table 1: Proposed Metadata Schema for Characterizing Online Labs [10]

#	Element Group	Element Name	Description	Vocabulary Element?
1	General Metadata	Title	Refers to the complete title of the online lab	No
2		Description	Provides a textual description of the online lab	No
3		Type	Refers to the specific type of the online lab	Yes
4		Language	Refers to the languages that the online lab is available in	Yes
5		Keyword	Refers to a set of terms that characterize the content of the online lab	No
6	Administrative Metadata	Access Permissions	Refers to the online lab's access permissions (e.g. whether the online lab requires booking or registration)	Yes
7		Rights Holder	Refers to those entities that hold the online lab's copyrights	No
8		Lifecycle Dates	Refers to critical dates related to the online lab's lifecycle	No
9		Contact Details	Provides information about contact details of the person or the organization responsible for the online lab	No
10		Cost	Refers to any payment required for using the online lab	Yes
11		Licence	Provides information about copyrights and restrictions applied to the use of the online lab	Yes
12		Provider	Provides information about the provider of the online lab	No
13		Contributor	Refers to each person (or entity) that has contributed in the making of the online lab in its current state	No
14		Version	Provides information about the current version of the online lab	No
15		Status	Provides information about the availability status of the online lab	Yes
16	Pedagogical Metadata	Subject Domain	Refers to the online lab's subject domain	Yes
17		Age Range	Refers to the age range for which the online lab can be used	Yes
18		Educational Objectives	Refers to the educational objectives that the online lab addresses	No
19		Level of Difficulty	Refers to the level of difficulty of the online lab	Yes
20		Level of Interaction	Refers to the level of interaction to the online lab offers	Yes
21	Technical Metadata	Location URL	Provides a URL for accessing the online lab	No
22		Technical Requirements	Refers to the technical requirements that are needed for using the online lab.	Yes
23	Additional Material Metadata	Student's Resource	Refers to the type and the URL of student's resource that is connected to the online lab	No
24		Teacher's Resource	Provides the URL for accessing any lesson plan that can be used for exploiting the online lab	No
25		Supportive App	Provides the URL for accessing any supportive app that is connected to the online lab	No

As the Table 1 depicts, our proposed metadata schema includes 25 metadata elements divided in 5 metadata elements groups, namely i) General Metadata (5 elements), ii) Administrative Metadata (10 elements), iii) Pedagogical Metadata (5 elements), iv) Technical Metadata (2 elements) and Additional Material Metadata (3 elements). This metadata schema will be used for characterizing the online labs that will be collected in our study and they will be described in the next section.

ISBN 978-615-5511-06-6

Study Methodology

In this section, we present the methodology that has been adopted in our study. More specifically, we present the process for selecting our sample of online labs, namely the search terms used the inclusion criteria applied, as well as the procedure that was followed.

Sample

In order to select a substantial number of online labs we performed web searches, between February and May of 2015, using the Google search engine, as well as existing repositories of online labs that have been reviewed in our previous work [10]. The search terms included: "*virtual laboratory*", "*remote laboratory*", "*data set*", "*analysis tool*", "*virtual and remote laboratory*", "*virtual and remote lab*", "*online laboratory*", "*e-laboratory*", "*repository for virtual laboratories*", "*repository for remote laboratories*", "*repository for virtual and remote laboratories*", "*repository for online laboratories*".

Due to the fact that the number of online labs that are currently available on the web is considerably high, we explicitly determined a set of inclusion criteria for the sample (Table 2).

Table 2: Inclusion Criteria

Online labs that are offered under an open access license
Online labs that address STEM fields, namely Science, Technology, Engineering, Mathematics
Online labs that address school education age ranges
Online labs that do not require third party plugins (such as Java, flash, MS Silverlight)
Online labs that are developed with HTML 5.0 technologies

The search process, and after deleting the duplicate records, yielded 185 online labs. These online labs were characterized with educational metadata following the metadata schema that was presented in section 2.

Procedure

In this section, we present the procedure that was followed for analyzing the educational metadata records of the online labs of the sample. More specifically, the analysis of the educational metadata records was focused on metadata elements that are "vocabulary elements", that is, elements that can be filled with a limited set of pre-determined values established by the metadata schema presented in section 2. The metadata elements that were selected to be analyzed were key elements of the presented metadata schema. More precisely, these were elements of the General Metadata, namely Type, as well as elements of the Pedagogical Metadata, namely Subject Domain, Age Range, Level of Difficulty and Level of Interaction

The next step was to measure the entropy of values (as proposed in [11]) contained in the aforementioned elements in order to determine the amount of information they carry. Entropy as a measurement of information contained in a message was proposed by Shannon [12] and it denotes the variety of information included in this message. Small values denote small variety of the information included in the message. For example, if all the metadata

ISBN 978-615-5511-06-6

records in our sample have the field "Type" set as "Virtual Lab", a new instance with this field set to "Virtual Lab" carries little information, meaning that it does not help to distinguish this particular Online Lab from the rest. On the other hand, if the new educational metadata record has the "Type" field set to "Remote Lab", it is highly possible (based on the online labs of our sample) that this value helps to differentiate this new Online Lab from the others. The entropy values for the aforementioned vocabulary data elements has been calculated following the formula below, which has been proposed in [11]:

where: *times(value)* is the number of times that the vocabulary value is present in this metadata field in the educational metadata records of our sample and *n* is the total number of educational metadata records, namely 185 for the sample of online labs that has been collected. When times(value) is 0 (the value is not present in the repository), the Entropy is 1. On the other hand, if times(value) is equal to n (all the instances have the same value), the Entropy is 0.

For each of the aforementioned metadata elements, entropy values have been calculated and they are presented in the next section. Further to the calculation of the entropy values for each metadata element, we have calculated the occurrence frequency of each vocabulary value per metadata element within our sample of online labs.

Results: Analysis of Educational Metadata

In this section, we present the results from the analysis of the educational metadata records of the online labs in our sample. More specifically, the Figures 1, 3, 5, 7, 9 present heat map views of the entropy values for the different vocabulary values of the metadata elements: i) "Lab Type", ii) "Subject Domain", iii) "Age Range", iv) "Level of Difficulty", v) "Level of Interaction". Moreover, the Figures 2, 4, 6, 8, 10 present the occurrence frequency of the vocabulary values of the aforementioned metadata elements within the metadata records of our sample.

Lab Type	Entropy
Virtual Lab	0,094431878
Remote Lab	0,239459522
Data Set	0,435969678

Figure 1. Heat map Table of the Entropy Values for the Vocabulary Values of the Metadata Element "Lab Type"

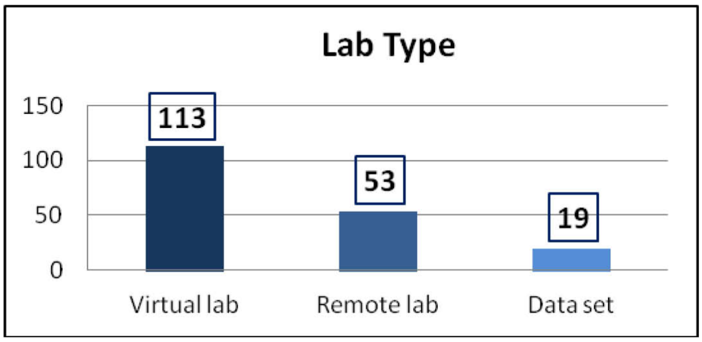

Figure 2. Occurrence Frequency of the Vocabulary Values of the Metadata Element "Lab Type"

Subject domain	Entropy
Science	0,029909948
Maths	0,436693366
Technology & Engineering	0,567030248

Figure 3. Heat map Table of the Entropy Values for the Vocabulary Values of the Metadata Element “Subject Domain”

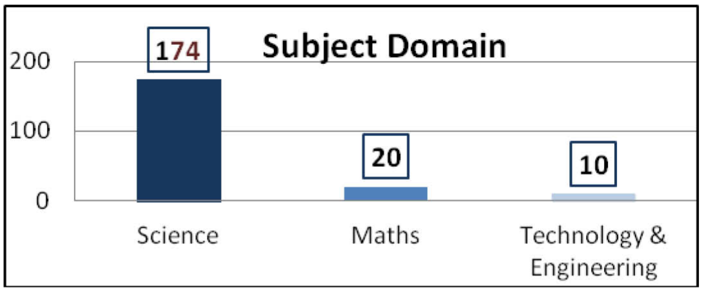

Figure 4. Occurrence Frequency of the Vocabulary Values of the Metadata Element “Subject Domain”

Age Range	Entropy
14-16	0,201127497
16-18	0,215391854
12-14	0,225685179
10-12	0,315317543
8-10	0,569216292
6-8	0,784608146

Figure 5. Heat map Table of the Entropy Values for the Vocabulary Values of the Metadata Element “Age Range”

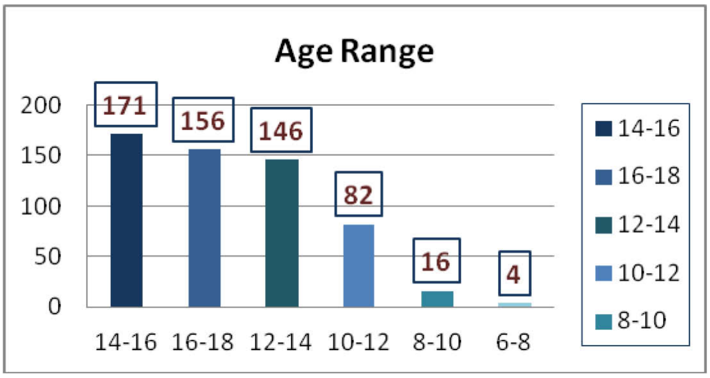

Figure 6. Occurrence Frequency of the Vocabulary Values of the Metadata Element “Age Range”

Level of Difficulty	Entropy
Medium	0,081328801
Easy	0,25844116
Advanced	0,468888939

Figure 7. Heat map Table of the Entropy Values for the Vocabulary Values of the Metadata Element “Level of Difficulty”

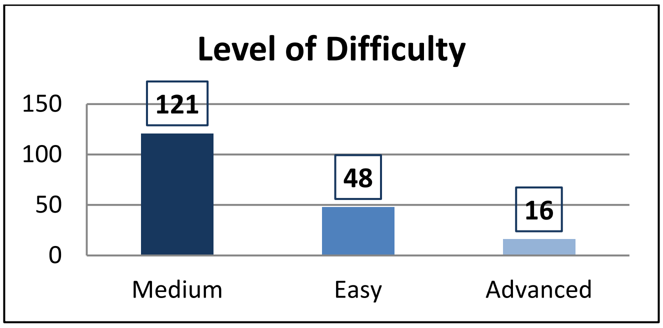

Figure 8. Occurrence Frequency of the Vocabulary Values of the Metadata Element “Level of Difficulty”

Level of Interaction	Entropy
High	0,078188438
Medium	0,243108353
Low	0,558921811

Figure 9. Heat map Table of the Entropy Values for the Vocabulary Values of the Metadata Element “Level of Interaction”

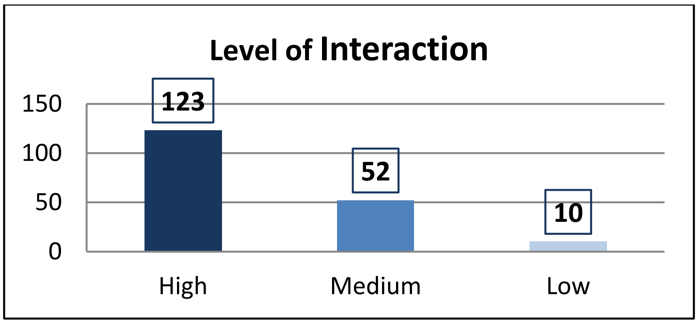

Figure 10. Occurrence Frequency of the Vocabulary Values of the Metadata Element “Level of Interaction”

ISBN 978-615-5511-06-6

ISBN 978-615-5511-06-6

Based on the aforementioned metadata analysis results, we can notice the following main findings:

Virtual labs are dominant in our sample. This can be explained by the fact that virtual labs are not very costly to implement, whereas remote labs require specialized equipment and they are difficult to develop and costly to maintain. Finally, data set analysis tools are not very frequent in our sample because their development requires specialized knowledge of the structure and format of the data set and this might be hindering factor for interested parties to develop them and offer them online.

Most of the online labs support science education. This can be explained by the fact that most of the online labs are used to engage students in science experiments. However, there are also some online labs that can be used for engaging students in understanding and exploring mathematical concepts, as well as technology & engineering concepts.

The dominant age ranges in our sample are those that are related to secondary education age ranges, namely 12-14, 14-16, 16-18, whereas there are limited online labs that address primary education age ranges, namely 6-8, 8-10, 10-12. This can be explained by the fact that most school curricula engage students in the process of conducting experiments mainly during secondary education.

The dominant level of difficulty in our sample is medium, whereas online labs with level of difficulty easy and advanced are limited. This means that most of the online labs in our sample can be operated by the students with the assistance from their teachers. This can be explained by the fact that most online labs of our sample address secondary school education and at this grade level, online labs of medium difficulty are needed towards engaging students in understanding and exploring challenging STEM concepts.

The dominant level of interaction in our sample is high, whereas online labs with level of difficulty easy and advanced are limited. This means that most online labs in our sample requires from the students to manipulate many variables in order to operate them. This can be explained by the fact in most cases online labs are needed in order to provide students the capability to engage deeply in the experimental process.

Conclusions and Future Work

In this paper, we presented an analysis of the educational metadata records of online labs that were collected and it is expected to be included in the online labs repository of the Go-Lab Project (http://www.golabz.eu/). The Go-Lab project aims to establish an online portal that facilitates the federation of existing virtual and remote labs [13]. Based on the metadata analysis presented in this paper, we concluded that the main trends of online labs that are currently available online: i) are mainly virtual labs, since these type of online labs are not very costly to implement, ii) support the science subject domain, since they are used to engage students in science experiments, iii) support secondary school education, since most school curricula engage students in the process of conducting experiments during secondary

ISBN 978-615-5511-06-6

education and iv) are of medium difficulty and high interactivity level. Future work in this agenda will be performed in two axes, as follows: i) we will further analyze this sample towards producing additional conclusions for other characteristics of existing online labs (i.e. technical or administrative characteristics) and ii) we will focus on the development of recommender mechanisms that can facilitate STEM teachers in the process of selecting online labs for their day-to-day teaching activities.

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Acknowledgement

The work presented in this paper has been partially funded by the European Commission in the context of the Go-Lab project (Grant Agreement no. 317601) under the Information and Communication Technologies (ICT) theme of the 7th Framework Programme for R&D (FP7). This document does not represent the opinion of the European Commission, and the European Commission is not responsible for any use that might be made of its content.

ISBN 978-615-5511-06-6

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ISBN 978-615-5511-06-6

CHARACTERIZING DIGITAL EDUCATIONAL TOOLS FOR SCHOOL STEM EDUCATION USING EDUCATIONAL METADATA

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Introduction

Science, Technology, Engineering and Mathematics (STEM) education has been recognized as a top priority for school education worldwide [1]. To support this, major initiatives have been developed to engage students in interesting and motivating STEM experiences [2], [3]. As it has been highlighted by several policy reports, such initiatives should follow the inquiry based teaching model [4]. Inquiry is the process in which students are engaged in scientifically oriented questions, perform active experimentation, formulate explanations from evidence, evaluate their explanations in light of alternative explanations, and communicate and justify their proposed explanations [5]. Inquiry based learning can be supported and enhanced with several Digital Educational Tools (DETs) that are available online, which can provide to the students ample opportunities for engaging in the inquiry process [6], [7].

However, existing DETs are scattered around the web without a commonly accepted method for characterizing them. This a hindering factor for STEM teachers to search and retrieve efficiently and effectively DETs for further usage into their day-to-day inquiry-based teaching activities. Under this light, the aim of this paper is twofold: i) to collect a sample of DETs that are currently available online and characterize them with a common educational metadata schema and ii) to perform an analysis of the educational metadata of the collected DETs towards providing insights about their characteristics.

The remainder of the paper is as follows. Section 2 presents the background of this work, namely the different types of DETs and their main characteristics, as well as the selected metadata schema that has been used for describing the collected sample of DETs. Section 3, presents the methodology that was followed for collecting the sample of DETs and the metrics that were used for the metadata analysis. Section 4, presents the analysis of specific metadata elements for the collected DETs and it provides useful insights about their characteristics. Finally, section 5 concludes the paper and presents potential future work.

Background

Types of Digital Educational Tools for STEM Education

Within the rich literature, there are many types of DETs for STEM education [6], [7], [8], [9], [10]. Based on a literature review that we have performed, we can identify eight (8) main distinct types of DETs for STEM education, as follows:

- **Remote Labs:** these are physical laboratories that can be operated at a distance and they provide students with the opportunity to conduct real experiments and collect real data from a physical laboratory in a remote location [11].
- **Virtual Labs:** constitute interactive environments for designing and conducting simulated experiments. More specifically, they can range from simple simulations of physical processes that allow students to manipulate few variables to accurate simulations of experimental processes complemented with functionalities to measure experimental errors [12].
- **Data Set Analysis Tools:** data sets are outcomes of investigations with physical or virtual equipment. They often come with dedicated analysis and visualization tools that help to organize and interpret the dataset [13].
- **Virtual Reality Tools:** these tools contain the following features: i) the illusion of being in a 3-D space, ii) the ability to build and interact with the 3D objects, iii) digital representation of students in form of avatars, and iv) ability to communicate with other students in the virtual reality tool [14].
- **Augmented Reality Tools:** they are tools that provide students with technology-mediated immersive experiences in which real and virtual worlds are blended, as well as students' interactions and engagement are augmented [15]
- **Modelling Tools:** these are tools with calculation, exploration and visualization functionalities and they can be used for learning abstract STEM concepts, as well as key elements of scientific modelling. It could be concept modelling tools or hypothesis generation tools [16]
- **Assessment Tools:** they are tools that can be used by the students, in order to assess their competences and get feedback about their inquiry process. It could be quiz tools or drill and practice tools [17].
- **Educational Games:** these are learning environments that provide students with a sense of autonomy, identity, and interactivity towards reaching specific educational goals. They are equipped with achievement levels, and rewards systems. Students in these environments can strategize their moves, test hypotheses, and solve problems [18].

Metadata Schema for Characterizing Digital Educational Tools for STEM Education

A major European Initiative, namely the Inspiring Science Education (ISE) Project (http://www.inspiring-science-education.org/) has already developed a metadata schema for characterizing DETs for STEM education. This metadata schema is presented in Table 1.

ISBN 978-615-5511-06-6

Table 1: ISE Project Metadata Schema for Characterizing Digital Educational Tools for STEM Education

#	Element Group	Element Name	Description	Vocabulary Element?
1	General Metadata	Title	Refers to the complete title of the DET	No
2		Description and Primary Aims	Provides a textual description of the DET, as well as its primary aims	No
3		Type	Refers to the specific type of the DET	Yes
4		Language	Refers to the languages that the DET is available in	Yes
5		Keyword	Refers to a set of terms that characterize the content of the DET	No
6	Administrative Metadata	Registration	Denotes whether accessing DET requires registration)	Yes
7		Rights Holder	Refers to those entities that hold the DET's copyrights	No
8		Lifecycle Dates	Refers to critical dates related to the DET's lifecycle	No
9		Contact Details	Provides information about contact details of the person or the organization responsible for DET	No
10		Cost	Refers to any payment required for using DET	Yes
11		Licence	Provides information about copyrights and restrictions applied to the use of the DET	Yes
12		Provider	Provides information about the provider of the DET	No
13		Status	Provides information about the availability status of the DET	Yes
14	Pedagogical Metadata	Subject Domain	Refers to the DET's subject domain	Yes
15		Age Range	Refers to the age range for which the DET can be used	Yes
16		Educational Objectives	Refers to the educational objectives that the DET addresses	No
17		Level of Difficulty	Refers to the level of difficulty of the DET	Yes
18		Level of Interaction	Refers to the level of interaction to the DET offers	Yes
19	Technical Metadata	Location URL	Provides a URL for accessing the DET	No
20		Technical Requirements	Refers to the technical requirements that are needed for using the DET.	Yes
21	Additional Material Metadata	Student's Manual	Refers to the URL of student's manual for using the DET	No
22		Teacher's Resource	Provides the URL for accessing the lesson plan that can be used for exploiting the DET	No

As the Table 1 depicts, the metadata schema includes 22 metadata elements divided in 5 metadata elements groups, namely i) General Metadata (5 elements), ii) Administrative Metadata (8 elements), iii) Pedagogical Metadata (5 elements), iv) Technical Metadata (2 elements) and Additional Material Metadata (2 elements). This metadata schema will be exploited in our study for characterizing the sample of DETs that has been collected, as it will be described in the next section.

Study Methodology

The scope of this section is to present the methodology that has been adopted in our study. More specifically, we present the process for selecting our sample of DETs, namely the search terms used the inclusion criteria applied, as well as the procedure that was followed for analyzing the educational metadata records of our sample.

Sample

In order to select a considerable amount of DETs we performed web searches, between February and May of 2015, using the Google search engine. The search terms included: "*virtual laboratory*", "*remote laboratory*", "*data set*", "*analysis tool*", "*virtual and remote*

ISBN 978-615-5511-06-6

laboratory", "virtual and remote lab", "online laboratory", "e-laboratory", "virtual reality tool", "VR tool", "augmented reality tool", "AR tool", "modelling tool", "assessment tool", "e-assessment", "educational game", "digital game".

Due to the fact that the number of DETs that are currently available on the web is considerably high, we explicitly determined a set of inclusion criteria for the sample (Table 2).

Table 2: Inclusion Criteria

DETs that are offered under an open access license
DETs that address STEM fields, namely Science, Technology, Engineering, Mathematics
DETs that address school education age ranges
DETs that address the inquiry-based teaching model
DETs that do not require third party plugins (such as Java, flash, MS Silverlight)
DETs that are developed with HTML 5.0 technologies

The search process, and after deleting the duplicate records, yielded 195 DETs. These DETs were characterized with educational metadata following the metadata schema that was presented in section 2.

Procedure

In this section, we present the procedure that was followed for analyzing the educational metadata records of the DETs of the sample. More specifically, the analysis of the educational metadata records was focused on metadata elements that are "vocabulary elements", namely, elements that can be filled with a limited set of pre-determined values established by the metadata schema presented in section 2. The metadata elements that were selected to be analyzed were key elements of the presented metadata schema. More precisely, these were elements of the General Metadata, namely Type, as well as elements of the Pedagogical Metadata, namely Subject Domain and Age Range.

The next step was to measure the entropy of values contained in the aforementioned elements in order to determine the amount of information they carry. Entropy as a measurement of information contained in a message was proposed by Shannon [19] and it denotes the variety of information included in this message. Small values denote small variety of the information included in the message. For example, if all the metadata records of in our sample have the field "Subject Domain" set as "Science", a new instance with this field set to "Science" carries few information, meaning that it does not help to distinguish this particular Online Lab from the rest. On the other hand, if the new educational metadata record has the "Subject Domain" field set to "Mathematics", it is highly possible (based on the DETs of our sample) that this value helps to differentiate this new DET from the others. The entropy values for the aforementioned vocabulary data elements has been calculated following the formula below, which has been proposed in [20]:

ISBN 978-615-5511-06-6

where times(value) is the number of times that the vocabulary value is present in this metadata field in the educational metadata records of our sample. n is the total number of educational metadata records, namely 195 for the sample of DETs that has been collected. When times(value) is 0 (the value is not present in the repository), the Entropy is 1. On the other hand, if times(value) is equal to n (all the instances have the same value), the Entropy is 0. For each of the aforementioned metadata elements, entropy values have been calculated and they are presented in the next section. Further to the calculation of the entropy values for each metadata element, we have calculated the occurrence frequency of each vocabulary value per metadata element within our sample of online DETs.

Results: Analysis of Educational Metadata

In this section, we present the results from the analysis of the educational metadata records of the online labs in our sample. More specifically, the Figures 1, 3, 5 and 7 present heat map views of the entropy values for the different vocabulary values of the metadata elements: i) "DET Type", ii) "Subject Domain" and iii) "Age Range". Moreover, the Figures 2, 4, 6 and 8 present the occurrence frequency of the vocabulary values within the educational metadata records of our sample.

DET Type	Entropy
Virtual Lab	0,265844617
Remote Lab	0,336903498
Modelling Tool	0,368062813
Assessment Tool	0,368062813
Virtual Reality Tool	0,405368011
Educational Game	0,431873217
Augmented Reality Tool	0,583306512
Data Set Analysis Tool	0,660201096

Figure 1. Heat map Table of the Entropy Values for the Vocabulary Values of the Metadata Element "DET Type"

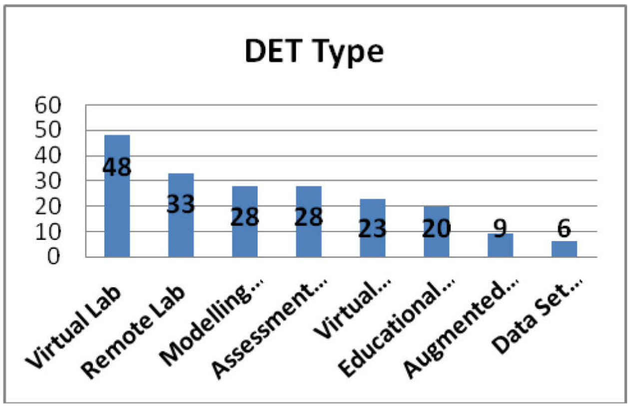

Figure 2. Occurrence Frequency of the Vocabulary Values of the Metadata Element "DET Type"

Subject Domain	Entropy
Science	0,104019789
Mathematics	0,178638491
Technology & Engineering	0,572002040

Figure 3. Heat map Table of the Entropy Values for the Vocabulary Values of the Metadata Element "Subject Domain"

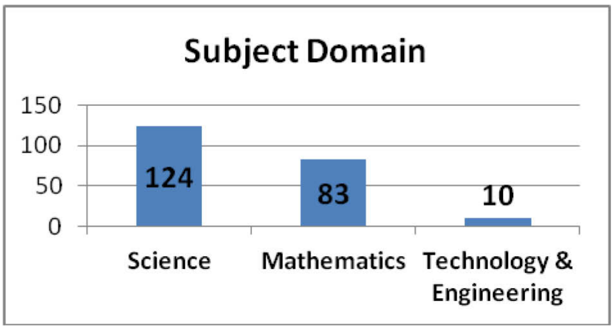

Figure 4. Occurrence Frequency of the Vocabulary Values of the Metadata Element "Subject Domain"

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Subject Domain: Science	Entropy
Physics	0,193106057
Astronomy	0,342231739
Chemistry	0,392387939
Biology	0,412362144
Geography and Earth Science	0,412362144
Environmental Education	0,611644026

Figure 5. Heat map Table of the Entropy Values for the Vocabulary Values of the Metadata Element "Subject Domain" for the Value "Science"

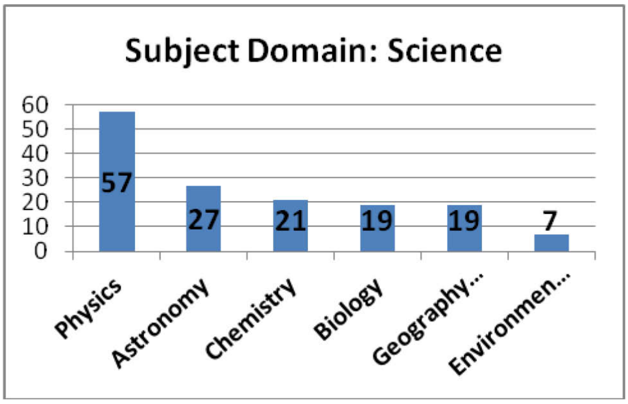

Figure 6. Occurrence Frequency of the Vocabulary Values of the Metadata Element "Subject Domain" for the Value "Science"

Age Range	Entropy
9-12	0,167504434
12-15	0,246885262
15-18	0,259481541
6-9	0,295783156

Figure 7. Heat map Table of the Entropy Values for the Vocabulary Values of the Metadata Element "Age Range"

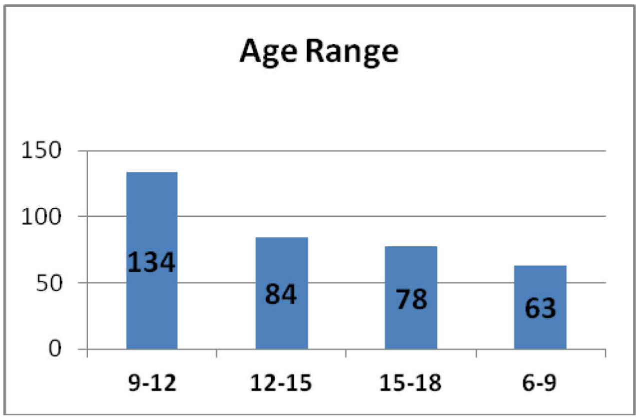

Figure 8. Occurrence Frequency of the Vocabulary Values of the Metadata Element "Age Range"

Based on the aforementioned metadata analysis results, we can notice the following main findings:

Virtual labs are dominant in our sample. This can be explained by the fact that virtual labs are not very costly to be implemented and they don't require advanced technical skills. On the other hand, other types of DETs such as augmented reality tools or data set analysis tools require advanced technical skills (rendering, visualizing and augmenting real objects for the case of augmented reality tools) and specialized knowledge (structure and format of the data set for the case of data analysis tools) to be developed. Finally, all other types of DETs are almost equally distributed in our sample, which means that there are no main hindering factors for interested parties to develop them and offer them online for use in STEM education

Most of the DETs can support science education. This can be explained by the fact that most of the DETs are mainly used to engage students in science experiments. However, there are also a considerable amount of DETs that can be used for engaging students in mathematical concepts, as well as technology & engineering concepts. Moreover, it is worth mentioning that the dominant sub-subject of science education that is addressed by most DETs is Physics. This

ISBN 978-615-5511-06-6

is explained by the fact the Physics includes many concepts that can be taught with DETs and following the inquiry process.

The age ranges in our sample are almost equally distributed. This means that DETs for supporting inquiry based teaching are used to both primary (6-9 and 9-12 age ranges) and secondary education (12-15 and 15-18 age ranges). This can be explained by the fact that most of school curricula worldwide aim to engage students in the inquiry process during the whole spectrum of school education.

Conclusions and Future Work

In this paper, we presented an analysis of the educational metadata records of DETs that were collected from relevant searches on the web. Based on this analysis, we concluded that the main trends of DETs that are currently available online: i) are mainly virtual labs and modelling tools, ii) support the science subject domain and more specifically physics and iii) can support both primary and secondary education. Future work in this agenda will be performed in three axes, as follows: i) we will further analyze this sample towards producing additional conclusions for other pedagogical characteristics of existing DETs (i.e. interactivity level and difficulty level), as well as other characteristics of existing DETs (i.e. technical or administrative characteristics), ii) we will focus on offering the DETs that have been collected via existing web repositories of DETs such as the repository that has been developed by the Inspiring Science Education Project (http://portal.opendiscoveryspace.eu/repository-tool) and iii) we will focus on the development of recommender mechanisms that can facilitate STEM teachers in the process of selecting DETs for their day-to-day inquiry-based teaching activities.

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Acknowledgement

The work presented in this chapter has been partly supported by the Inspiring Science Project that is funded by the European Commission's CIP-ICT Policy Support Programme (Project Number: 325123). This document does not represent the opinion of the European Commission, and the European Commission is not responsible for any use that might be made of its content.

ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

MODERN METHODS OF INTRODUCING BASIC PHYSICS CONCEPTS: THE COORDINATES AND THE GPS

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Motivation

In order to transform the very young student in an active person which, guided by teachers, discovers and scrutinizes new knowledge territories, there are new teaching strategies in agreement with student's learning manners:

- the lesson should embrace questions and activities that involve the student;
- as part of the lesson, one uses a combination of activities which tackle different learning manners that the student prefers: visual, auditory, practical;
- the lesson involves an active participation of the student in the learning process, through accomplishing experiments, simulations and problems by means of a computer, even when the students start to study/discover Physics.

In education the increase in efficiency is determined by the development of permanent learning competences and of students' and teachers' creative skills. According to Ausubel, "the most important single factor influencing learning is what the learner already knows".

Thus, meaningful learning results when a person consciously and explicitly ties new knowledge to relevant concepts they already possess. When meaningful learning occurs, it produces a series of changes within our entire cognitive structure, modifying existing concepts and forming new linkages between concepts. This is why meaningful learning is lasting and powerful whereas rote learning is easily forgotten and not easily applied in new learning or problem solving situations which the present science curricula so advocate.

So, taking into account that the 6-graders are at the very beginning of their Physics study, these "anchors" should be secured into the foundations they got from the study of other subjects. The scientific content must be embedded in a variety of curriculum patterns that are developmentally appropriate, interesting and relevant to the student's lives. The program of science study should connect to other school subjects. The curriculum must put more emphasis on connecting science to other subjects, such mathematics, chemistry, biology, geography, and less emphasis on treating science as a subject isolated from other school subjects.

Use of computers and ICT software tools in classrooms and laboratories provide much more effective and efficient environments in teaching and learning, making physics a science easier to understand. The advantages of using simulation software in conjunction with classroom teaching are well known. It is generally accepted that the use of interactive teaching tools, which provide instant feedback to the student's inputs, improve and accelerate the learning process. The use of simulations and ICT tools in secondary education is not a new concept. In order to lead the young aspiring scientist's mind toward complex experiments, solid fundaments must be laid down from the very beginning.

Short description/ main idea

The purpose of this paper is to point out an interactive method to introduce basic physics concepts to youngest students. I will emphasize the way one can use modern methods such as GPS localization, educational software and geographic maps, in order to lure students into developing experimental skills. I will focus upon the advantages of this kind of approach. Finding out about and understanding typical mathematical concepts, terminology and calculations procedures, and using educational computer software during the teaching-learning-assessing process, the students can have outstanding achievements.

Studying physics in such an interdisciplinary and interactive way could be at the same time funny but nonetheless rigorous!

Target:

- Schools: Schools which adopt curricula focused on Mathematics, Physics, Sciences and Computer Science;
- Classes: Classes that allocate a greater number of lessons weekly for subjects like Mathematics, Natural Sciences, or Computer Science;
- Students: Student from grades 6 and 7.

Available learning capabilities

- Group of moderate learning pace students (remedial education)
- Group of rapid learning pace students (academic performance sustention)

Curriculum areas/ domains involved

- Physics, Mathematics, Geography, Computer Science

Key competence

Achieving knowledge that allows for both remedial education and exceptional academic performance sustention

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Objectives

The main objectives are:

- supporting students hands-on learning of science;
- delivering hands-on activity resources to educators;
- pointing out anchor-knowledge necessary in teaching new concepts, and training the students in the area of conceptual and operational structures constructions;
- integrating the achieved knowledge and intellectual strategies into a derived general scientific frame;
- uncovering areas of special need that may be difficult to identify without special assessment;
- inspiring the next generation of engineers and scientists;
- integration of the achieved knowledge and intellectual strategies into a derived general scientific frame.

Students will:

- practice using maps;
- understand the underlying principle responsible for the working of the GPS;
- use a GPS unit and understand latitude and longitude coordinates;
- understand the importance of avoiding measurements errors;
- understand the importance of adopting adequate units;
- use mathematical calculations to solve practical problems;
- be able to use a GPS unit to conduct scientific inquiry and demonstrate that changes in motion can be measured and graphically represented;
- be able to distinguish between scalar and vector quantities, between displacement and distance, between velocity and speed.

Phases

Phase 1: Preparation

The teachers will established:

- The teaching strategies:
  - Teaching-learning methods: explanation, heuristic conversation, proof, phenomena modelling, systematic observations, problems posing.
  - Academic means: exercise books, educational software (PC, smartboard).
- Implementing method:
  - Front-end

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Phase 2: Implementation (Activities)

The structure of the lessons will consist of three modules, each representing an important activity, which the teacher can assemble at its own will or skip altogether. Students getting acquainted with the underlying principle responsible for the working of the GPS.

2D and 3D student-made animations will be used. The animations were developed by Cristian Zaharia and Matei Militaru, former students from the Tudor Vianu National High School of Computer Science, under my guidance and supervision. Some basic concepts regarding measurement and orientation, such us maps, units, measurement errors and coordinates, will be introduced (see/GPS http://portal.opendiscoveryspace.eu/beta/educational-objects/70475).

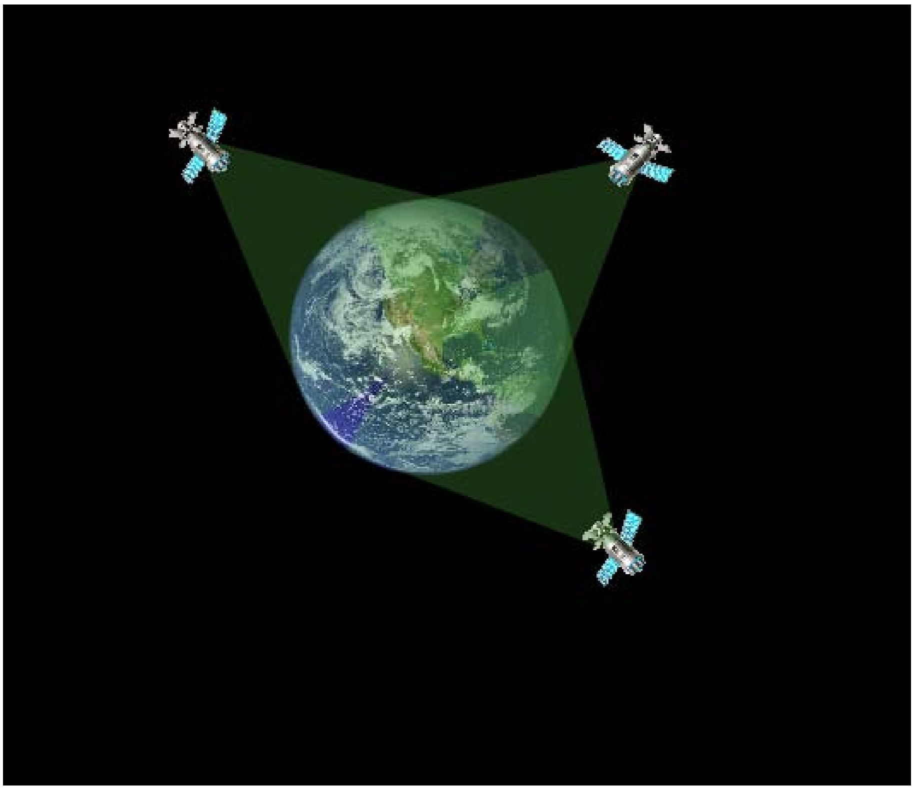

Figure 1. Screenshot from the GPS Educational Software

Educational game software: reading maps and making use of adequate units, the students will find on the maps certain given locations, acting similar to the working of the GPS. They will have to solve riddles, use mathematical hints, transformations of units and changes of coordinates, which will all point toward those locations (see/use the GPS_PLAY educational software http://portal.opendiscoveryspace.eu/beta/educational-objects/70475 and the attached work sheet). See snapshots of the physics class at Liceul Teoretic National: http://youtu.be/kNZlOlvZieo, http://youtu.be/kwj6B3rihaE.

ISBN 978-615-5511-06-6

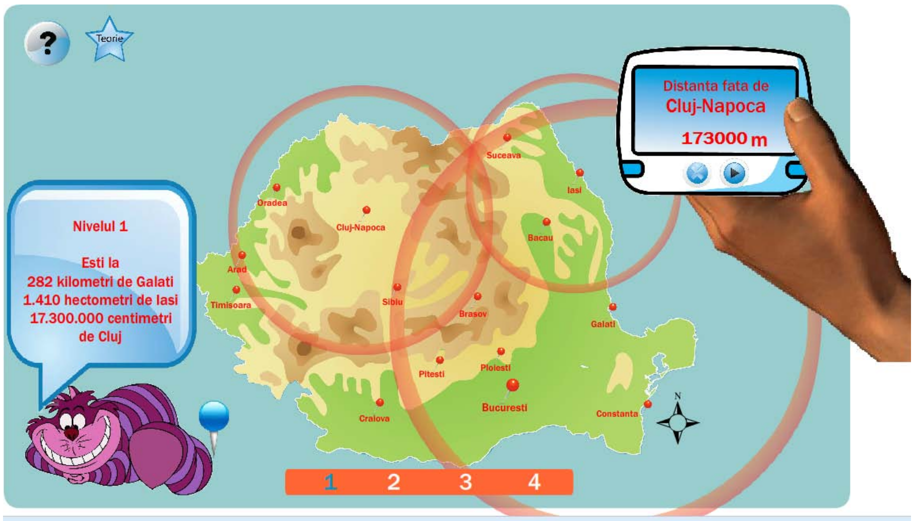

Figure 2. Screenshots from the Educational Software game

Phase 3: A hands-on activity

This activity will involve arbitrary measuring units in order to find a number of "treasures". The class will be split into two teams, and the students will be presented with their tasks. They will have to use the inner working of the GPS and to do simple calculations (Pythagoras' Theorem, units' transformations) and the teams will compete to discover the treasures as fast as possible in order to win the game. Each team will receive a working sheet with specific details.

Figure 3. Photos taken during the Hands-on Activity at Liceul Teoretic National

Phase 4: Assessment

The students will be assessed on the basis of the working sheets given at activity number 2 and of the educational software for the same activity. Each discovered place will be one mark. The students will receive grades proportional to the number of places/marks discovered with the help of the game. Supplementary, all the students from the winning team will be rewarded with maximum grades.

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Figure 4. Photos taken during the Hands-on Activity at Liceul Teoretic National

Parental engagement

The two expected benefits deriving from the parents' engagement in the scenario will be:

- an immediate one, aiming at convincing the parents to contribute to the transforming of the event representing the "The treasure hunting" contest into a real festival;
- a long time scale one, regarding the possibility for the parents to survey their children's progress by means of the internet and the virtual classbook;
- The parents will be able to know at any moment their children's marks (each of them will be given a password in order to have access to the virtual classbook) and they will communicate with the teacher via internet about their children's progress and the subsequent actions to be taken (remedial education or academic performance sustention);
- The parents' engagement in the scenario is intended to serve for a better ICT communication and parents/students/teachers team building;
- Last but not least, as active participants in applying methods that lie outside the classical teaching methods, the parents will get motivated to support morally the effort made by the teachers and students.

Advantages

The traditional teaching methodology used in secondary education is based mainly on oral speech and use of the blackboard. But it is important to generate understanding using situated examples, visualizations, and dialogues. By using situated examples, the teacher should make the students able to understand the software problem. The principles of the software are then

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explained through visualizations. Finally, the teacher gives the right sequence of software instructions showing the main implementation steps of the problem solving process.

On the other hand the students can use software principles to construct solutions to the problem through involvement in realistic task-based activities. The goal is for the students to construct their knowledge and to work at their own pace from their prerequisites. The teacher works as a mentor and guide of learning rather than as a transmitter of knowledge.

Another advantage offered by this type of lessons is that it includes stimulation of the creativity and of the competition spirit, unconventional tests allowing for an optimal feedback, user-friendly working environments, individual and/or team work visual support, which all offer rapid understanding of even the most subtle and complex scientific themes. By means of an educational game, this lesson allows for a more intense involvement of each student into the learning process: the student will learn by playing in a rigorous mathematical way, because mathematics, creativity, logic, and originality are all needed to improve technology.

Figure 5. Photo taken during the Hands-on Activity at Liceul Teoretic National

- Using a cross-curricular approach, the students can get an encompassing view not only over Physics, but also over different another fields (mathematics, geography, computer science). The students will get to know the practical side of Physics and the way information from Physics can be used in other areas. They will study some basic and more complex directional skills so they can navigate nature and the greater biosphere.
- Through these lessons, students can access information in real time using GSP software, and can even get in contact with other students who work in the same environment. In this way they will develop working skills both individually and in team, as well as communication abilities and a competitive spirit.

The assessment is an unconventional one, allowing for an optimal feedback.

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ISBN 978-615-5511-06-6

The teacher who can choose certain lesson stages which are in accordance with topics from the school curriculum, but he/she can also create sequences based on the feedback received from a certain group of students, or on the strategies that he/she uses.

Conclusion

The teaching-learning-assessing process needs a student-teacher team, as well as needed to be active. Each didactic activity should be authentic, specific and oriented towards applications that will attract the student.

I strongly believe that the usage of modern technologies, such as GPS, and of educational software is a must for the educational process, an addition to the classical methods, appealing to the individual character of each student.

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Annex

WORK SHEET

IN THIS QUESTION YOU WILL BE GIVEN SOME INFORMATION ABOUT HOW FAR YOU ARE FROM THREE CITIES AND YOUR GOAL IS TO FIND YOUR LOCATION. THIS WILL MODEL HOW GPS SATELLITES LOCATE A POSITION.

Use the map of Romania handout and the clues below to locate the city that fits the criteria in the clues (the teacher can choose any map and locations).

- You are located 2154 Km from Bucharest.

a. If you only knew how far you were from Bucharest, at which points on the map could you be located? Label these points on the map.

- You are also located 1879 Km from Iasi.

b. If you only knew how far you were from Bucharest and Iasi, at which points on the map could you be located? Label these points on the map.

- You are also located 2464 Km from Brasov.

c. Write down the name of the city you have located.

d. The GPS uses information from four satellites. What extra information does using this many satellites provide?

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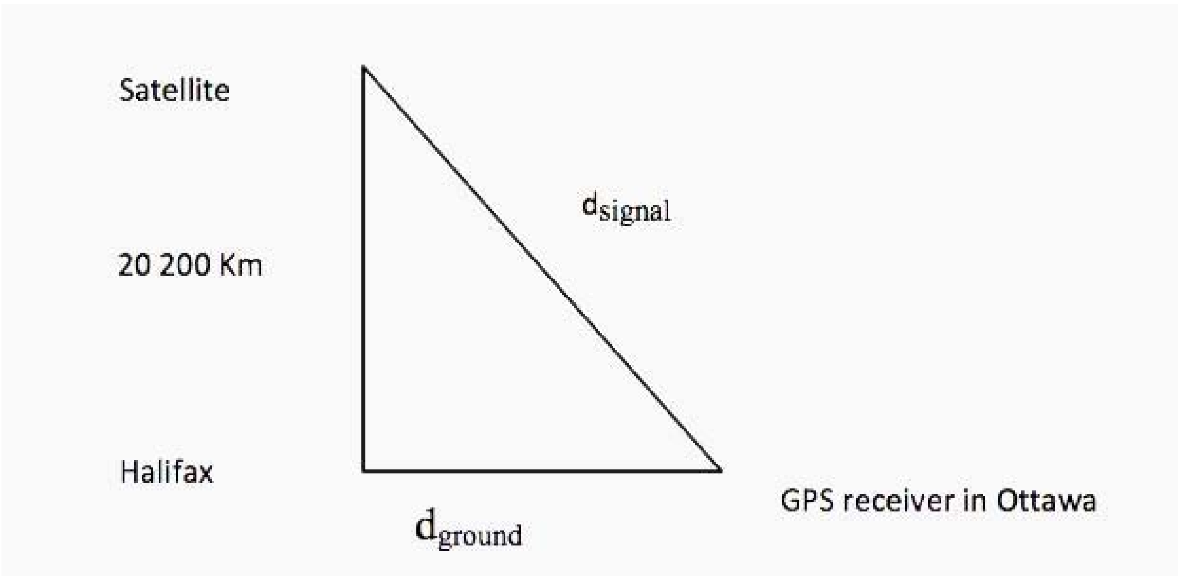
WE KNOW THAT A GPS SATELLITE ORBITS 20 200 KM ABOVE THE SURFACE OF EARTH.

Suppose a GPS satellite is over Halifax, Nova Scotia. We will calculate the time for the signal sent from the satellite to a GPS receiver in Ottawa, Ontario.

- To calculate this, measure the distance from Halifax to Ottawa: ______cm.
- Use the scale and record the number of kilometers from Halifax to Ottawa: ______Km.

- Using Pythagoras' Theorem calculate the distance the signal travels.
- Knowing the speed of the signal, 3.00 x 10^5 Km/s, and the distance the signal travels, calculate the transit time for the signal to reach the receiver from the satellite.



ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

INSPIRING SCIENCE EDUCATION: RESULTS ON STUDENTS' PROBLEM SOLVING CAPABILITIES USING 3 PILOT EDUCATIONAL SCENARIOS

Emmanuel Chaniotakis, Sofoklis Sotiriou, Ellinogermaniki Agogi, Panagiota Argyri, Evangelliki Sxoli Smyrnis, Greece

Abstract

An analysis of students' problem solving capabilities using the ISE assessment framework shall be presented. The data sample consists of 3 different ISE demonstrator runs with a group of students from age 13 to 17. The data were taken during the summer school 'The Class of Physical Sciences at the School of tomorrow' which took place from 17 to 21 July 2015 in Messini, Greece and was organised by the Association of Greek Physicists and Ellinogermaniki Agogi.

Description of the Inspiring Science Education Project

Inspiring Science Education (ISE) is a project funded by the European Commission under the CIP-ICT-PSP programme to encourage the use of eLearning tools for enhancing and fostering Inquiry Based Science Education in European Schools. The project runs with a multi-stakeholder partnership from 15 different European countries, including educational and training authorities, pedagogical experts, science research teams, museum educators, European associations and school networks, educational outreach experts, teachers' communities, highly innovative ICT companies and eLearning solutions developers. The mission of the Inspiring Science Education team is to provide digital resources and opportunities for teachers to help them make science education more attractive and relevant to students' lives. Through the Inspiring Science Education website and the activities organised by the partners, teachers can help students make their own scientific discoveries, witness and understand natural phenomena and scientific practices and access the latest, interactive tools and digital resources from within their classrooms.

Inquiry Based Science Education implementation with ISE

ISE is concerned with supporting teachers to organise and sequence inquiry-oriented and technology enhanced learning experiences for their students effectively. On these grounds, ISE follows an instructional model of Inquiry Based Science Education in order to provide an instructional model for teachers to help them organise their educational scenarios. This model consists of five inquiry phases: i) Orienting and Asking Questions; ii) Hypothesis Generation and Design; iii) Planning and Investigation; iv) Analysis and Interpretation; v) Conclusion and Evaluation.

In each stage of an educational scenario, students are engaged in an innovative learning experience using the ISE environment. Each inquiry phase is accompanied with cutting edge eLearning interactive tools, virtual resources as well as means of assessment for both students' understanding of the content of the educational scenario and their problem solving competencies.

Problem Solving Competency assessment in ISE

The ISE concept of problem solving competency is based on the framework developed by OECD for use to assess the individual problem solving competency of 15-year olds in the Programme for International Student Assessment (PISA) 2012. Following the PISA 2012 paradigm, ISE focuses mainly on the cognitive processes required to solve real world problems. These can be described as four distinct processes: 'Exploring and Understanding'; 'Representing and Formulating'; 'Planning and Executing'; and 'Monitoring and Reflecting'. Each of these processes corresponds to the first four inquiry phases, thus leading to the possibility to assess the students' partial problem solving skills per process using the ISE environment. The questions are designed to address the cognitive capabilities of students on problem solving and thus are largely independent on the knowledge prerequisites of the corresponding educational scenario.

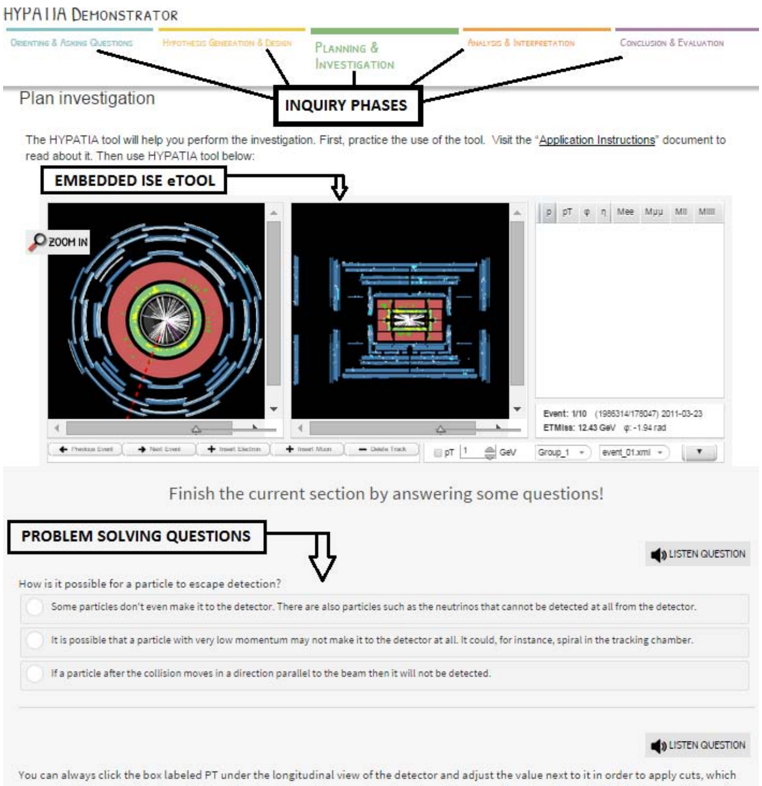


Figure 6. ISE educational scenario environment

The problem solving questions in ISE have the following architecture: Each inquiry phase from i) to iv) is concluded with two problem solving questions. Questions are multiple choices with three correct options each. Every possible answer corresponds to the student's level of proficiency in problem solving according to the following categorisation:

- **Low Performers**: Students who can only partially describe the behaviour of a simple, everyday topic and can also answer if a single, specific constrain has to be taken into account.
- **Moderate Performers**: Students who can control moderately complex devices, but not always efficiently. They can also handle multiple conditions or inter-related features by controlling the variables.
- **High Performers**: Students who can develop complete, coherent mental models of different situations. They can find an answer through target exploration and a methodological execution of multi-step plans.

The results and real time class statistics of the problem solving questions for each ISE demonstrator are available online for the teacher by choosing the 'Assessment' option of the ISE environment. Likewise, the assessment option gives the teacher the opportunity to monitor both the knowledge questions results and also the time elapsed per student per inquiry phase.

Data Analysis

The following analysis of students' problem solving competencies was carried out using data obtained during the summer school "The Class of Physical Sciences at the School of tomorrow" which took place from 17 to 21 July 2015 in Messini, Greece and was organised by the Association of Greek Physicists and Ellinogermaniki Agogi.

The data sample consists of 3 different ISE demonstrator runs with a group of Greek students from age 13 to 17, with more than 60% of them being 15 year olds.

The students were given 120 minutes per demonstrator in order to carry out the lesson. *All the participants of the summer school were chosen with a school-grade based criterion (having more than 16/20 grade at school) or a distinguished performance in physics competitions, which in general corresponds to a high level student sample.*

Demonstrators

The demonstrators used in order to collect the problem solving questions data were:

- The wonderful world of colours [4];
- HYPATIA Demonstrator [5];
- Eratosthenes Experiment [6].

The above demonstrators and the corresponding problem solving questions were designed for high school students. The lessons were delivered in Greek and they all contain interactive eTools and digital resources and follow the phases of inquiry based science education as described in the previous section.

Results

The wonderful world of colours:

- 21 students completed the lesson;
- 168 problem solving questions were answered in total.

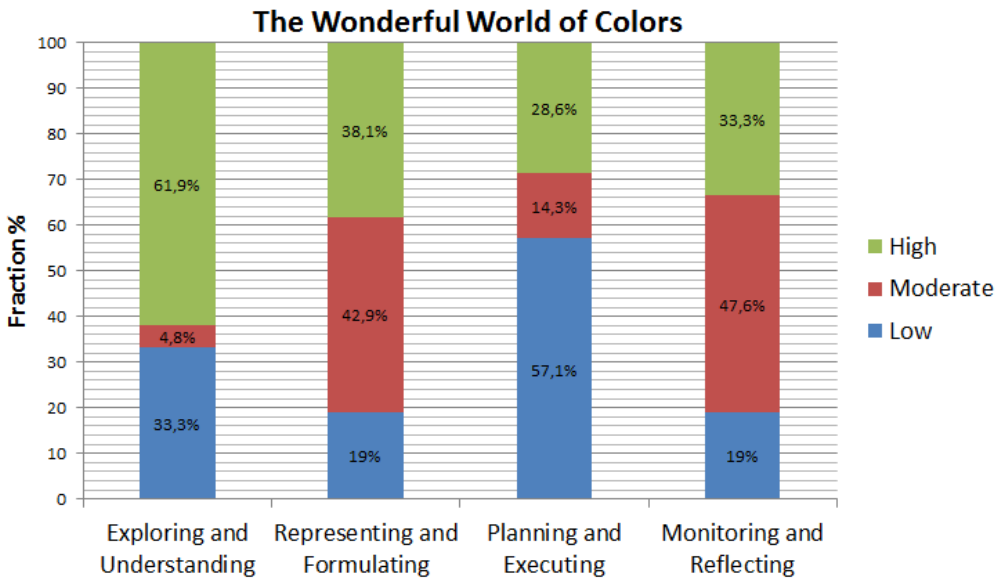


Figure 2. The students' profile per proficiency level for the 'Wonderful World of Colors' educational scenario

The figure above shows the students' profile per proficiency level. The results are obtained by the following procedure: For each student, we keep the lowest score of the two questions per proficiency level and add it to the chart.

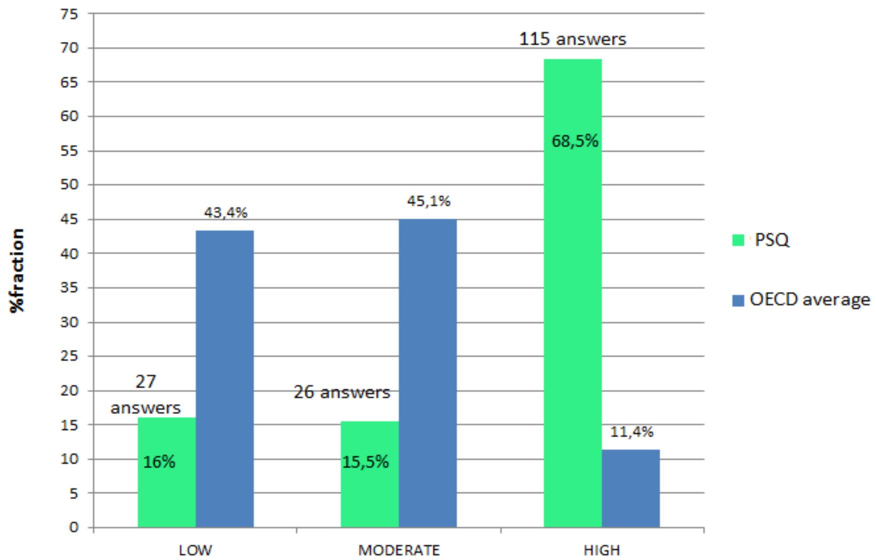


Figure 3. The fraction of low, moderate and high performers for the 'Wonderful world of colors' educational scenario. Results of the analysis are presented with green. OECD average is presented with blue.

The figure above shows the fraction of answers to the problem solving questions marked as low, medium and high as obtained from the analysis of the data for this educational scenario, whereas the blue bars display the OECD average for comparison. The results were obtained by calculating the fraction of the questions answered, marked as 'low', 'medium', and 'high'.

We observe that the fraction of low and moderate answers is very low (16%), whereas the high achievers' answers reach 68.5%.

HYPATIA:

- 31 students completed the lesson;
- 248 problem solving questions were answered in total.

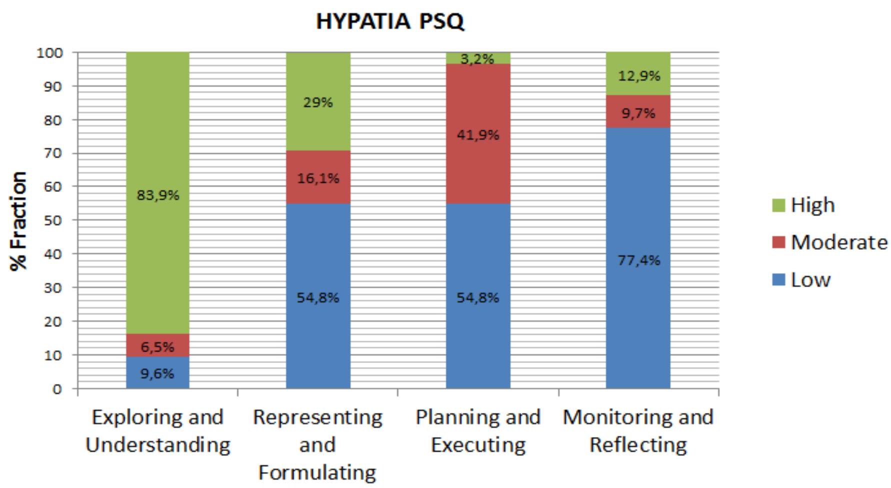


Figure 4. The students' profile per proficiency level for the 'HYPATIA' educational scenario

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EDEN Open Classroom Conference Proceedings, 2015, Athens
ISBN 978-615-5511-06-6

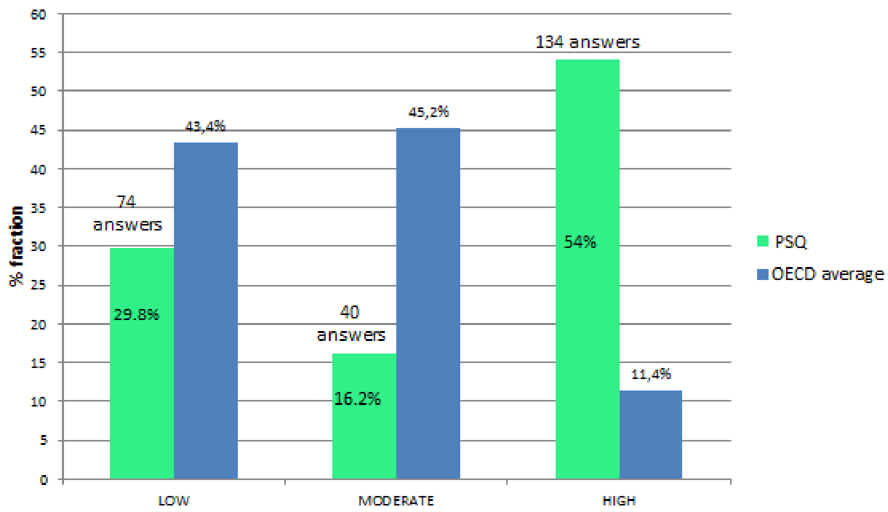

Figure 5. The fraction of low, moderate and high performers for the 'HYPATIA' educational scenario. Results of the analysis are presented with green. OECD average is presented with blue.

We observe that 54% of the questions answered correspond to high achievers, compared to less than 30% low achievers.

Eratosthenes Experiment:

- 22 students completed the lesson;
- 176 problem solving questions were answered in total.

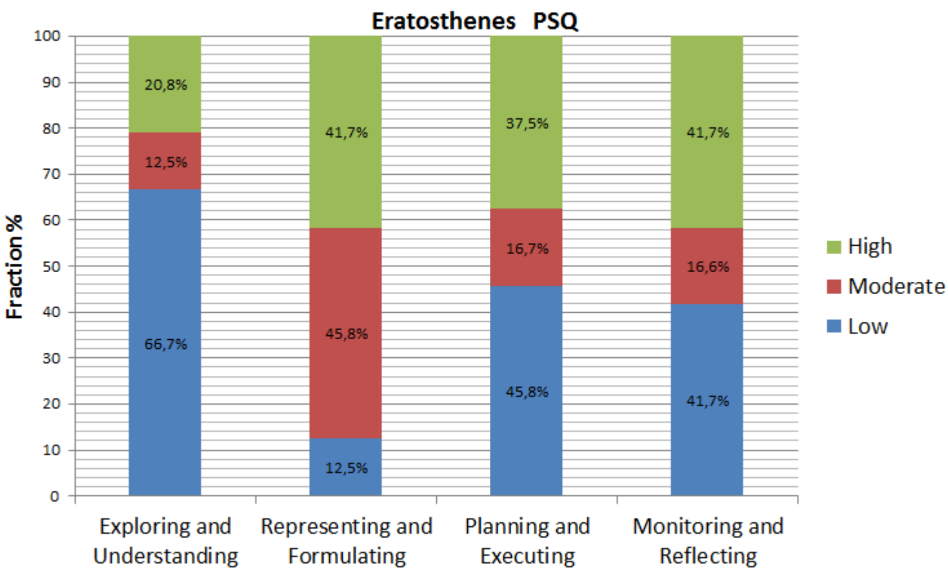

Figure 6. The students' profile per proficiency level for the 'Eratosthenes Experiment' educational scenario

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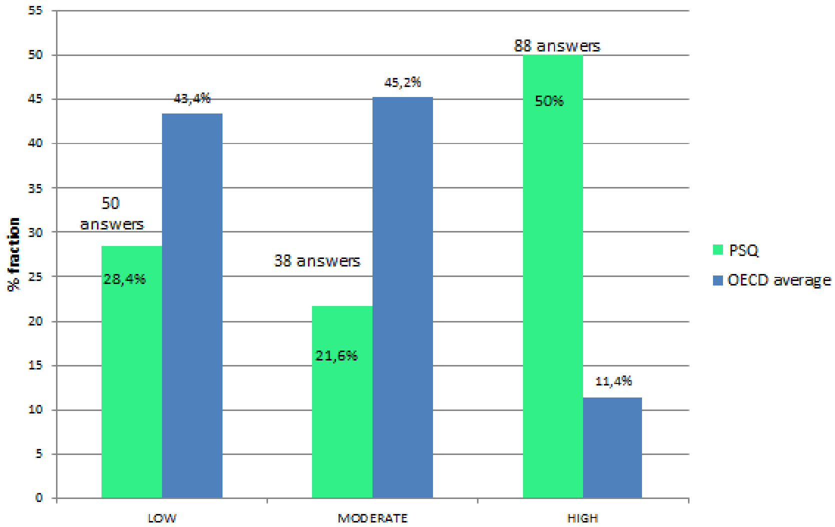

Figure 7. The fraction of low, moderate and high performers for the 'Eratosthenes Experiment' educational scenario. Results of the analysis are presented with green. OECD average is presented with blue.

We observe that 50% of the questions answered correspond to high achievers compared to 28.4% low achievers.

Conclusions

A problem solving competencies analysis of a group of students from 13 to 17 years old students, using 3 pilot educational scenarios implemented at the ISE environment was presented.

For all the runs we observe that in an overall estimation, equal or more than 50% of the students are high achievers with less than 30% being low achievers. This successful result comes in agreement with the summer school participants' profiles. The students' profile per proficiency level depends strongly on the individual characteristics of each demonstrator, with the high achievers fraction of the 'Representing and Formulating' process being similar within 10%.

The same runs are planned to be repeated during the 2015-2016 school year in international level with a much bigger student sample of different ages, cultures and education levels. Data will be received and compared with results from international summer schools such as the one presented here and will be repeated next year.

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6. http://tools.inspiringscience.eu/delivery/view/index.html?id=02d6608031f043ca8d73254c9f4b9c86&t=p

ISBN 978-615-5511-06-6

Transforming Schools into Innovative Learning Organisations
Proceedings of the European Distance and E-Learning Network 2015 Open Classroom Conference
Athens, 18-21 September, 2015
ISBN 978-615-5511-06-6

CULTIVATING THE 21ST CENTURY SKILLS IN THE MICROCONTOLLERS LAB

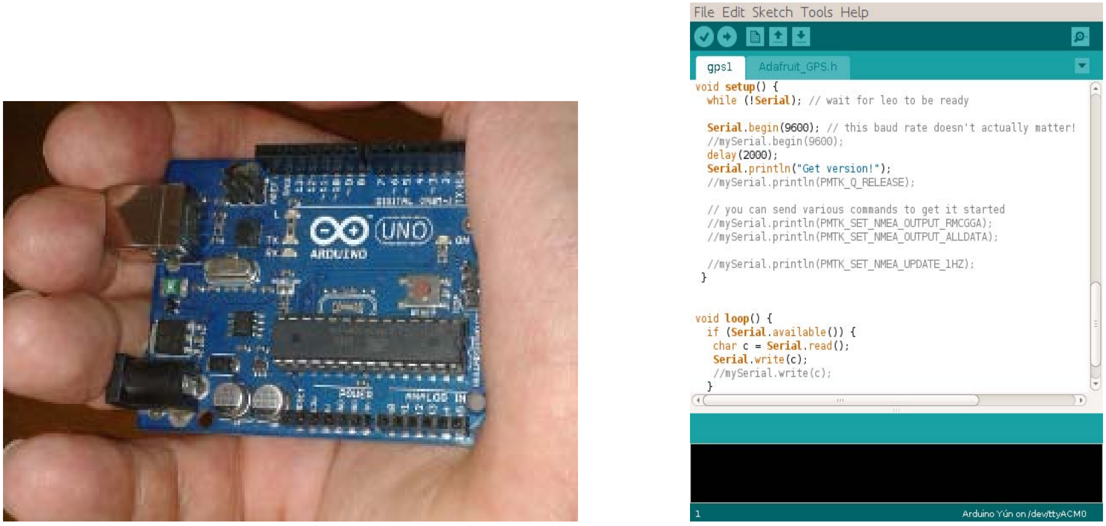
Antonios Andreatos, Hellenic Air Force Academy, Greece

Introduction

This paper is a case study on the educational policies and learning methods used by the Computer Engineering and Information Science Dept. of the Hellenic Air Force Academy. In order to build the background, the underlying learning theories will be mentioned; next, the so-called 21st century skills will be presented; a few words about the operation of the Microcontrollers Lab will follow. Then we shall describe the policies used for cultivating the 21st century skills.

The Arduino platform

In the Microcontrollers Lab of the Computer Engineering and Information Science Dept. we use the Arduino board as an educational and experimental platform. Arduino is a series of low cost, free and open source software (FOSS) and open hardware microcontroller boards (www.arduino.cc; https://en.wikipedia.org/wiki/Arduino; see Figure 1a). Arduino provides an inexpensive, easy and fast way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples for beginner hobbyists include simple robots, thermostats and motion detectors (www.arduino.cc; https://en.wikipedia.org/wiki/Arduino). The first Arduino was introduced in 2005 and since then, its spread worldwide was unprecedented. The open-source Integrated Development Environment (IDE) includes a large number of FOSS working examples (Figure 1b). The board can be connected to a computer via a USB port. Through this port and the IDE, the code may be uploaded to the Arduino board and the microcontroller can send results back to the computer.



(a) (b)

Figure 1. Arduino board (a) and IDE (b)

Due to its FOSS nature, user-friendliness and wide range of automation applications, a vast community of Arduino enthusiasts has been created and includes region specific groups and special interest groups (For instance: http://scuola.arduino.cc/, http://www.fabiobiondi.com, https://codebender.cc/). The official Arduino forum (http://forum.arduino.cc) hosts posts in many languages but many more local national user communities also exist. *International Arduino day* (https://day.arduino.cc/#/) was celebrated in 2014 and 2015. Figure 2 shows a map of events held worldwide on the International Arduino day 2015 (March 28th, 2015).

Arduino is a good candidate platform for introductory programming as well as technology courses, such as those of the Greek Lyceum curriculum. The wealth of available information about Arduino on the Web covers any possible problem, supports many topics (for instance, see http://forum.arduino.cc/), covers many ambitious projects and is therefore offered for learning by discovery. MOOCs about Arduino are also available online (for instance, https://www.udemy.com/arduino-sbs/learn/#).

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Figure 2. Events held worldwide on Arduino DAY 2015

The educational scenario

In our Microcontrollers Lab the exercises are implemented in groups of three students, using Arduino and a set of cheap, off-the-shelf components such as LEDs, resistors, sensors, speakers, etc. (Andreatos, 2015). The first educational examples are demonstrated by the instructor on a projector, and junior students, typically 20-21 years old, have the possibility to reproduce the experiments step-by-step, in real time. The instructor also demonstrates a technique for recording the whole experiment in a brief video, using the laptop's webcam and a set of FOSS tools (Andreatos, 2015). Students are supposed to use this technique in order to record their own videos.

According to Vygotsky's social constructivism (Vygotsky, 1962), this process develops the student's ability to do the same tasks on their own, without help or assistance (Andreatos, 2012).

Student identification issues

One of the major reforms in modern formal education is the infusion of face-to-face instruction with technology-enhanced learning. The proliferation of Web 2.0 tools and low-cost portable computing devices enables teachers to assign project work to students, to be fulfilled outside of the classroom. In our case, the lab hours are not enough for the students to complete the lab curriculum, which also foresees a complex team project in the end. Project-based learning (PBL) is being used systematically by our Division because it has proven to be a great way of learning (Andreatos, 2005; Andreatos, 2009). Given that all our students are given laptops and can acquire an Arduino board at low cost, they can work on their own out of the class schedule. Moreover, students which were absent during the lab hours, are given the opportunity to complete the missed exercises at their own convenience, either in the lab or

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even at home, without supervision by the instructor. In both cases, the students have to prove: i) their identity; ii) that they were able to complete the exercise.

Proposed solution

The instructor has chosen to solve the above two problems is the following way: by the end of each exercise, students have to deliver two things: i) a report in digital format containing a description, their code, links and photographs taken by their smart phones, and ii) a video taken by their laptop's webcam, demonstrating the stages and the completion of the exercise, the date, the code and the students' faces. The instructor selects the best video for each exercise and uses it as educational material for the following academic years.

The underlying learning theories

Contructivism is being used systematically by our Division because it has proven to be a great way of learning (Andreatos, 2005; Andreatos, 2009).

The idea that learning is an active process was first expressed by J.S. Bruner in 1966 (Culatta, 2013; see http://www.instructionaldesign.org/theories/constructivist.html). Bruner proposed that learners construct their own understanding of a subject by engaging in activities and building on past knowledge and experience. A lot of modern learning theories such as active learning, problem-based learning, experiential learning, learning by discovery, collaborative learning and computer-supported collaborative learning (Andreatos, 2009) have been influenced by constructivism. Therefore, today's constructivism is not a single theory but rather a number of related theories and perspectives associated with ideas of active learning (Andreatos, 2012).

Vygotsky put the bases of social constructivism in his theory of the "Zone of Proximal Development" (Vygotsky, 1962). Vygotsky stated that a child following an adult's example or working in collaboration with an adult, gradually develops the ability to do certain tasks without help or assistance (Andreatos, 2012).

Application of Constructivist learning theories

By having the instructor demonstrating the use of the Arduino board and IDE on the one hand, and the process for creating educational videos using common equipment on the other, we apply Vygotsky's social constructivism. By having the students work together in teams we apply social constructivism and collaborative learning. Learning by discovery, as well as, PBL, are used in the project (Andreatos, 2005; 2009; 2015).

Social capital

During the past four years a considerable social capital has been created in our Lab, shared among students and staff. This consists of imported sources such as books about Arduino, as well as, in-house educational material such as the Lab handout, the educational videos and past projects. In 2013, our lab organised an introductory Arduino seminar during the FOSSCOMM 2013 conference (FOSSCOMM [Free and Open Source Software Communities]

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is a Greek conference aiming at Open Source enthusiasts, developers, and communities https://en.wikipedia.org/wiki/Fosscomm#FOSSCOMM_2013_Athens).

Students have access to the educational material produced around the Arduino during the last four years; they also discuss various issues with their senior fellows (which have completed the course a year ago); in these ways, they access the lab's social capital. Their work will feed and enrich the social capital. The best projects are described in the lab handout which is revised and extended every year.

Due to this process, each year the experiments and the projects get more and more complex; it has been observed that each new academic year, newcomers in the Lab get exposed to an increased social capital and are therefore capable of implementing more complicated projects than past years.

The 21st century skills

The 21st century skills are a set of abilities that students need to develop in order to succeed in the information age. In order to prepare today's children for tomorrow's world, the Partnership for 21st Century Skills (http://www.p21.org/) and the International Society for Technology in Education (http://www.iste.org/) have drafted frameworks and guidelines that outline what our students need to know to meet the challenges of the modern age. Mastery of core content areas, such as language, mathematics, science and history, remains the centrepiece. But these two organisations emphasize the importance of cultivating interdisciplinary themes, such as global awareness and financial, civic and health literacies, and weaving key skill areas (creativity and innovation, communication and collaboration, research and information fluency, and critical thinking, problem solving and decision making) into core subject matter (http://newtech.coe.uh.edu).

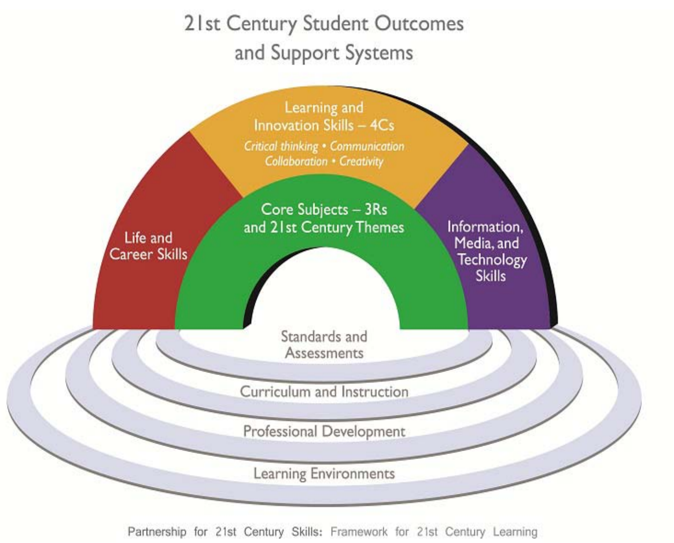

Figure 3. The 21st century skills (Souce: http://www.p21.org/)

21st century skills are critical for innovating and for operating more effectively and at lower cost (Fonstad & Lanvin, 2010). Therefore, 21st century skills are an important consideration

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for every educator striving to prepare today's students for the competitive global market of tomorrow (http://newtech.coe.uh.edu).

Similarly, Care and Griffin (2010) identify ten primary 21st century skills organised within four thematic areas:

1. Ways of Thinking (Creativity and innovation; Critical thinking, problem solving and decision making; Learning to learn and metacognition);
2. Ways of Working (Communication; Collaboration);
3. Tools for Working (Information literacy including research on sources, evidence, bias, etc.; ICT literacy);
4. Living in the World (Citizenship – local and global; Life and career; Personal and social responsibility including cultural awareness and competence) – (Care & Griffin, 2010).

Table 1: Ten key 21st century skills organised within four thematic areas Source: Care and Griffin (2010)

Thematic areas	**Primary 21st century skills**
1/ Ways of Thinking (3)	Creativity and innovation
	Critical thinking, problem solving and decision making
	Learning to learn and metacognition
2/ Ways of Working (2)	Communication
	Collaboration
3/ Tools for Working (2)	Information literacy including research on sources, evidence, bias, etc.;
	ICT literacy
4/ Living in the World (3)	Citizenship - local and global
	Life and career
	Personal and social responsibility including cultural awareness and competence

More or less, various research groups and organisations agree on similar sets of skills (e.g., Fonstad & Lanvin, 2010).

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The above scenario cultivates the following 21st century skills

The above scenario cultivates the following 21st century skills (Table 2):

Table 2: The 21st century skills and methods used for their cultivation

Primary 21st century skills	Method used
Creativity and innovation	Final project; project-based learning
Critical thinking, problem solving and decision making	Final project; project-based learning
Learning to learn and metacognition	Final project; project-based learning
Communication	Team work
Collaboration	Team work; social constructivism and collaborative learning
Information literacy including research on sources, evidence, bias, etc.;	Search for information about project, etc. Collaborative learning. Learning by discovery
ICT literacy	Learn by discovery how to find and process information, analyze & synthesize
Citizenship – local and global	Arduino is supported by communities and individuals worldwide; our lab constitutes such a community; thus students feel part of the international community of Arduino users
Life and career	Develop professional skills in the lab and in events
Personal and social responsibility including cultural awareness and competence	Our lab frequently participates in social and cultural events such as the FOSSCOMM conferences, where students present seminars and projects.

Conclusion

By applying modern learning theories in the lab practice, we manage to enhance the educational process, produce technically and educationally remarkable results and cultivate the 21st century skills. Using modern learning theories and practices, we strive to prepare our students for living and working in the information era. This is achieved at a low lost with the use of cheap components, as well as, available equipment such as laptops, webcams and smartphones and constitutes a contribution to well-known problems of distance learning labs (Andreatos, 2015; Fotopoulos et al., 2013; Kostulski & Murray, 2011) as well as, learner identification in e-learning courses.

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ISBN 978-615-5511-06-6