Making Learning Science Fun (SciFun)

Transnational Report for O1

Prepared by UPIT

State of the art research report on Science Education

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SciFUN Partners:

	Universitatea din Piteşti (UPIT) Georgeta Chirleşan E-mail: g.chirlesan@upit.ro URL: www.upit.ro
	Grupul pentru Integrare Europeană Ramona Ciucă E-mail: r.ciuca@gie.ro URL: www.gie.ro
	Centre for the Advancement of Research and Development in Educational Technology (CARDET) Charalambos Vrasidas E-mail: pambos@cardet.org URL: www.cardet.org
	University of Peloponnese Vasilis Koulaidis E-mail: koulaidi@otenet.gr URL: www.uop.gr
	INNOVADE LI Demetris Hadjisofoclis E-mail: info@innovade.eu URL: http://innovade.eu/
	Uniwersytet Lodzki Pawel Barczynski E-mail: pawelbarczynski@uni.lodz.pl URL: http://www.uni.lodz.pl/
	Louth and Meath Education and Training Board Sharon Maher-Bordalo E-mail: smaherbordalo@lmetb.ie URL: http://louthmeath.etb.ie/

Executive Summary

Many countries are experiencing decreasing number of students studying science, engineering and mathematics in secondary and tertiary education, and the percentage of science and technology graduates has declined in several EU countries. The consequence is that, the insufficiency in the necessary scientists to support the knowledge economy depends in large extent on the science and technology, is seen as a significant problem.

The results of research in science teaching show a number of shortcomings: negative attitudes, low self-efficacy and decreased interest in science and relevant subjects, poor results in international studies on science education in many EU countries, inadequate and stereotypical conceptions about science and scientists and differences in gender, race and socio - economic status.

The SciFUN project aims to increase student motivation and achievement in science and other disciplines and preparing European educators to engage students more involved in science education. It follows an innovative approach to teaching and learning science and doing fun and relevant learning contexts sciences for students.

The coordinator of SciFUN project is University of Pitesti, Romania. The partners are: Group for European Integration (Romania), Centre for Advancement of Research and Development in Education (Cyprus), University of Peloponese (Greece), Innovade Li Ltd., (Cyprus), University of Lodz, (Poland), Louth and Meath Education and Training Board, (Ireland).

This report summarizes the results obtained by the 7 partner institutions from Romania, Cyprus, Greece, Ireland and Poland during the desk-based and field-based research on state of the art regarding Science Education. The desk-based research was achieved through Literature and Curricula Reviews in science education – more specifically in areas as Science & Technology Education; Environmental Education; Multicultural and Civic Education; Informal Learning - while for the field research, the project consortium has designed and applied questionnaires & interviews to teachers and stakeholders and has performed Focus Groups with teachers and school staffs to identify teachers and students needs for increasing interest and motivation for science education, for children engaging better in learning science and for identifying ways to support the development of students' attitudes towards science, and essentially nurture an interest in choosing careers in science.

Thus, the report is structured in four parts:

Part 1 emphasizes the findings from the Literature Review

Part 2: Findings from the Curriculum Review
Part 3: Findings from the Questionnaires
Part 4: Findings from the Focus Group

The final part of this report consists of conclusions and recommendations for students and their educators and these will be used for subsequent project outputs, namely for developing useful guidelines and ideas for learning activities for science, cross curricular teaching units and the SciFUN toolkit.

Part 1: Findings from the Literature Review

In this part the main results from Literature Review are shown. This review emphasized that, in general, young students aged 9 to 15 years, are interested in studying science and technology and there is a good perception on science and scientists. For example, Cypriot students (70%) expressed positive attitudes towards science. Greek students think that science and technology (S&T) is important for society, makes our lives easier, healthier and more comfortable, but they do not think S&T can solve all problems of humanity. In Ireland, the attitude towards science depends on the type of class the students are in: the students in the lower classes would have generally a negative attitude towards science and a declining interest in science and the relevant subjects. Among the factors that relate to the students' attitude towards science, the researchers have identified the following: gender, age, education level, type of school (government or private school), the students' school results in sciences and their classmates' influence, self-image, social self-perception, their family's socio-economic status (parents' education, jobs and monthly income), teaching methods, parents' attitude towards sciences, the students' cognitive style, their interest in a certain type of career, social view on science and scientists.

The studies show that mathematics, physics, biology and chemistry are subjects which pupils learned with pleasure. A recent research on a service-learning program in Romania (IMPACT), recommends explicitly the need of an educational effort towards developing and encouraging the civic attitudes in youth and the participating in non-formal activities. However, the young generation achievements in sciences vary a lot among the partner countries participating in the survey. For example, In the PISA 2012 assessment of 15-year-olds, Greece showed below-average performance in science; furthermore, Greek girls perform better than boys in science, showing a statistically significant difference of ten points (the other countries show no such difference). Romania and Cyprus have appropriated performance regarding students' achievement in science and maths (the 47th, respective 46th out of 65 countries) according to Pisa 2012 (Programme for International Student Assessment). Irish students ranked 9th out of 34 OECD countries in the 2012 Pisa and Poland advanced to the forefront of the countries participating in the PISA study, not only in terms of the result, but also the dynamics of its growth.

Regarding the general perception about science and scientists, in all the researched countries the image prevailing in society about scientists and science is positive. In general, scientists are respected and trusted (in the Greek society) and children had developed stereotypical views about scientists (Cyprus, Romania and Poland). For Irish

students those who work in science have important jobs and careers. However, in other countries only very few young people dream of a career in science (Poland).

The researches upon the influence and effect of gender, race and socio-economic status on teaching science and science education indicate that there are significant gender differences in science education in Cypriot secondary schools, but not in elementary school. In all the countries participating in our research girls outperform boys in science education; females proved to be stronger in identifying scientific issues, while males were stronger at explaining phenomena scientifically (Romania). In Poland, there is a noticeable difference between the results of boys and girls in favour of girls, on literacy and interpretation, but there are no differences (statistically significant) in the performance in mathematics and natural sciences.

PISA results showed that the students with a more advantaged socio-economic background or those who had a parent in a science-related career were more likely to show a general interest in science and to identify how science may be useful to them (Poland, Romania, Ireland). In Greece, a socio-economic disadvantage does not seem to have a strong impact on student's performance.

Generally, one can remark higher scores in science results in private schools than in public schools.

Students' ethnic origin has not a significant role on science education, in all the countries participating in project.

A present trend in education is the utilisation of the Information and Communication Technology (ICT), in both teaching and learning of the scientific concepts. In Ireland teachers and students are using digital learning tools and resources such as Chromebook and Ipads and in Romania applications as: AeL (a Romanian learning platform developed by SIVECO ROMANIA SA), Moodle (a free web application - the educators can use it to create effective online learning sites) or LabVIEW software for Physics education (virtual and real experiments). Interactive and hands-on digital applications also seem to be very enthusiastically accepted by students (Greece).

In science education, the practical lessons rise the interest of students and the outdoors learning (e.g. outdoors field trips, visits to science museums) are preferred by kids, especially in Greek and Cyprus.

The students are also very interested in the socio-economic, practical and personal aspects of science and they like to learn about applications of science in various contexts of everyday life.

The involvement of students in project-based science (e.g. building up a solar car – Greece) or the participation in National science competitions such as the BT Young

Scientist and Scifest (in Ireland) are extremely successful in raising the profile of science and encouraging and motivating students to partake in science education.

Currently there are a lot of European Projects like SciFi Education project, which provided training courses and a Toolkit to in-service Science teachers to help improving teaching sciences by using SciFi literature, movies and ICT (www.scifieducation.org), or the "PROFILES: Education through Sciences" training program which form and develop specific competences of Science teachers in order to develop an educational process based on scientific inquiry and integrated approach of the Sciences curriculum.

Among the obstacles that could appear in teaching sciences our research could identify: a lack of classroom adaptation and equipment, shortage of time and too big number of pupils in class (Poland).

Part 2: Findings from the Curriculum Review

In this part the findings from Curriculum Review are presented.

The reviewed curricula envisaged a large scale of disciplines, from Physics, Mathematics, Natural Science, Environmental Education and Protection to Civic Education and Biology. Additionally, few more documents have been also analysed, namely the research report "Non-formal and informal education: realities and perspective within the Romanian school"; the research project "Improving Progress through Formative Assessment in Science and Mathematics Education", the research paper "Promoting Inquiry Based Science Education in Irish Primary schools", the article "Innovative initiatives: targeting the declining science enrolments in Ireland" and "Junior Certificate Science Draft Guidelines for Teachers".

It was found that in all reviewed curricula there are objectives referring – directly or indirectly - to promoting students' interest, motivation and engagement with science.

For example, in Romania, although in the analysed curricula one could not find direct or explicit objectives referring to promoting students' interest, motivation and engagement with science, many of the statements, recommendations and certain objectives emphasize – indirectly and overall - the promotion of science and pupils' interest for sciences. Two of the framework-objectives in the curriculum for Environmental Education and Protection are: "Knowing the environment by stimulating curiosity **to investigate the surrounding reality**" and "Developing a positive attitude towards nature by **carrying out environmental education activities**. Such an investigation requires skills and competencies specific to sciences, the quest for knowing the real world is highly motivating and the pupils will be thus oriented towards experimentation, critical thinking, analysis and reasoning, which are specific skills for the field of science education. Similar objectives exist in the curricula for Physics and Civic Education (knowing and explaining facts, events and processes from real life; applying best practices in everyday life; increasing applicability of the proposed content; applying in real life contexts the learned rules and regulations; using ICT to increase learning efficiency of studying physical phenomena).

In Poland, the "Core curriculum of preschool education and general education" specify objectives that directly promote student's interest, motivation and commitment to research. According to this document, the task of the school is to develop children's natural predispositions and cognitive abilities, to draw conclusions based on empirical observations of nature and society. "Every lesson of nature sciences should be like a performance, in which students feel like the most important actors, with a huge interest in the surrounding world and phenomena taking place in it."

The reviewed Greek curricula aim to motivate students through the connection of scientific knowledge with everyday life contexts. They emphasize on the utility of science and technology. Some of the objectives of the reviewed curricula are to help students suggest solutions for the improvement of the standards of living and the economic development of their place of living. Among the main priorities of the curricula there are also the development of the students' personality and the development of critical thinking. The curricula of technology and computer science mainly aim at helping students acquire basic knowledge and skills in the use of digital technologies.

In Ireland, the revised Junior Certificate syllabus (12-15 yr. old) places increased emphasis on scientific investigation and on the application of science process skills through student activities.

The following objectives are described in the Cypriot curriculum of science education (for the secondary school) to promote students' interest, motivation and engagement with science:

- to understand the fundamental concepts and subjects in science education and how these are connected and utilised in everyday life.

- to develop the ability to formulate evidence-based statements or question data and hypothesis through interactive discussion using critical and creative thinking.

- to acquire the ability to formulate views, as free, active and democratic citizens, participating in discussions and making decisions on subjects related to science education and relevant applications.

Romania does not have a national curriculum for informal/ non-formal learning, but formal education institutions should cooperate with providers of non-formal education to develop extracurricular activities, combining knowledge and methodologies of both types of education.

The objectives of developing non-formal education in Poland must comply with specified in Core Curriculum.

It should be noted that science represents the connection between motivating students and real life. And we may conclude that even when not the science itself is in the focus, science education or approach is however the basis for achieving the learning goals.

In all the reviewed curricula is provided guidance on the development of students' attitudes towards science. For example, in Romania, the methodological recommendations clearly envisage developing at students appropriate attitudes and behaviours towards science, through activities such as performing case studies ("Clean waters for all!", "Acid rains", "Air pollution"), achieving simple experiments (to

identify qualities of clean waters and fertile soil, etc.), attending activities organized by authorities in the field of environment protection), recycling wastes, etc.

Polish core curriculum indicates the need for shaping positive attitudes of students towards science by presenting: attitudes that determine effective and responsible functioning in the modern world, basic skills in nature research, attitudes of understanding of the importance of science for the development of society. For the middle school the curriculum makes a recommendation: "The school should devote much attention to the effectiveness of education in the natural sciences – in line with the priorities of the Lisbon Strategy. Education in this field is crucial for the development of Polish and European civilization".

The Greek curricula suggest methods of teaching, experimenting, cooperative engagement of students and self-directed learning that aim to enhance the students' interest for science and technology. Moreover, students understand the consequences of pollution of natural resources and the role of human activities in the degradation of the environment. The reviewed curricula also emphasize on the universal aspect of scientific language, which is seen as a promotion of the multicultural dimension of science.

Generally, the analysed curricula do not explicitly contain specific items regarding choosing a career in the field of sciences. But, the curricula are defined as an educational offer established at national level, consisting of a package of disciplines, differentiated on profiles (theoretical and technological) and specializations (in the case of vocational education). These educational offers provide the basis for preparing in the field of science and address the need to initiate the student specialized training routes, giving him/her a basis sufficiently diversified in order to orient him/her on subsequent studies or to make him/her becoming able to integrate, both socially and professionally, in case of graduation. In Poland, to propose or suggest a scientific career is the teacher's role.

The connection of science and technology to various aspects of the labor market and the importance of science and technology in society and our everyday lives (emphasized throughout the Irish curricula) could be nurturing students' interest in choosing careers in these fields.

By reviewing the general curricula of the Cypriot primary and secondary school, one can see that all students are urged to acquire and possess coherent and sufficient knowledge from all disciplines in order to be able to move on with their studies and contribute in the development of knowledge. However, there is no specific mention to the attempt of nurturing students' interest in choosing careers in science.

All reviewed curricula presented specific methods regarding how to increase students' interest, motivation and engagement in science. The frequent use of laboratory

exercises, which contributes to engaging students systematically with the experimental practice, are proposed in all curricula ('doing' rather than simply 'observing').

Polish core curriculum suggests that the way to increase student's interest in natural sciences is shaping and developing scientific reasoning skills and the use of the scientific method. It recommends the direct involvement of students and participation in practical activities. Pupils have to carry out observation and experiments. In addition, the core curriculum in each subject, indicates precisely the problems, methodology of scientific researches and a list of observation and experiments recommended for the implementation.

The Greek curriculum proposes to students to participate in team work and learn to work in a cooperative context. Project-based learning is also suggested as a means for enhancing students' engagement with the relevant subjects, exciting their curiosity and helping them in cultivating critical thinking and problem solving skills. The use of digital technologies in science education is also proposed as a tool for increasing students' interest and engagement in science. By using relevant applications, difficult and abstract scientific concepts can be demonstrated and explained, while students use tools much more attractive and familiar to them.

Regarding the civic education, the Romanian curriculum for high school requires the involvement of students in cooperation amongst them in order to solve theoretical and practical problems, their participation in the decision making and problem solving process in their community in order to motivate and encourage them to engage in the manifestation of a responsible and active social behaviour.

In order to promote students' interest, motivation and engagement in science, the curriculum of secondary education in Cyprus pays attention to the following: observation of phenomena; reflection and formulation of questions and assumptions; design and implementation of experimental approaches; recording, evaluation and analysis of measurements; presentation of data; support or reject initial assumptions; draw conclusions, generalisations and predictions. In addition, there are some general mentions to the nature of the methods used and the necessity to always lead to knowledge, be contemporary and effective.

In all of the reviewed curricula there were identified gaps regarding the promotion of the students' engagement in science. These are linked with the particularities of each educational system.

In Romania, the gaps occur between the existing practical/ applied studies in science – which is a consistent provision - and the deficiency of laboratories (not adequately equipped with the necessary facilities and equipment). On the other hand, one of the

most significant gaps is represented by the training need of teachers and other types of learning facilitators from the perspective of complementing and exploiting ways of non formal and informal learning in the school curriculum. Taking into account that non-formal education is based on providing real life situations, teachers could nurture, by non-formal education, their students' interest in choosing careers in science, especially in the present situation in which the curricula does not contain dedicated section for this issue.

In Poland, shaping the pupils' interests for science is affected not only by the curricula but by the educational practice too. Analysis of the mandatory experiments indicated in the Core Curriculum, together with limited number of teaching hours and the large classes in terms of pupils contained, allow concluding that there is a gap between expectations and real, practical capability of educational system. The real level of knowledge and students' skills may not be sufficient to create strong and lasting link with the science.

Greek students see science as something distant, objective, undisputedly true, and expressed by a very dry and technical language. Furthermore, curricula do not present the arguments concerning the nature of science and emphasize a lot on knowledge acquisition and not so much in exciting the curiosity of students.

There is a gap in the Irish curriculum in encouraging the integration with subjects such as music and art. Music can help to illustrate a science topic while at the same time science can help the musician to understand the making of music. This can be achieved through topics such as investigating sound and pitch, and making simple musical instruments. The study of light and colour, photography, and textiles provide natural links between science and the arts.

In the Cypriot science education curriculum, a few gaps were identified regarding the promotion of the students' engagement in science. Firstly, the curriculum is mainly focused on defining the goals towards a better engagement of students in science. The indicative activities of the curriculum for primary schools are not appropriate either for teachers neither for students. Secondly, in the current science education curriculum, there is no clear mention of any additional ICT tools besides the most commonly used ones (such as computer and projector); students do not often have the opportunity of being engaged with an experiment. Lastly, the books and handbooks have much space for improvement regarding the way they are organised and the illustration.

Regarding the policies or strategies to increase, motivate and stimulate children of 9 15 years to science education or young adults in science careers, all students are legally guaranteed equal access to education and to study in the fields of science and the possible creation of a scientific career.

In Romania, in addition to policies in the field many surveys, studies and international projects have been implemented to encourage students to get more involved in studying sciences. Moreover, the National Strategy for Research, Development and Innovation 2014-2020 has been launched and is currently in progress, a strategy which foresees increasing the role of science in society and supporting smart specialization through understanding the social impact of science, technology and economic activities in the relevant sectors. The strategy supports measures to attract young people to science, in the formal education and beyond, through measures such as: attracting talented young people to research careers by organizing contests (with prizes) for innovative solutions or establishing a City of Science close to a cluster of innovation or major infrastructure.

In Poland and Romania, the students who are particularly talented and interested in the natural sciences may also (at every stage of education) participate in extracurricular activities. They can also take part in contests and subject competitions at national and international level.

Polish extraordinary talented students can receive scholarships and be supported by governmental and non-governmental organizations such as "Foundation for Polish Science", "Polish Children's Fund", “Foundation for the Development of the Education System”. Ministry of Education (alone or with the participation of partner organizations and foundations) conducted a public campaigns showing the role of science in society, its impact on the development of technology and the improvement of living and promoting science as a future career for young people with a particular focus on women.

In Greece, the education policies and teaching strategies follow the structure of academic science which is not likely to be engaging for the majority of children. Only few scattered efforts, such as science festivals or science competitions, are undertaken at local level but there is no central coherent strategy behind these initiatives. The curricula propose learning methods such as experimentation and project-based or inquiry based learning, while they also suggest some visits in science museums and exhibitions. Furthermore, schools often lack the infrastructure or the expertise necessary to engage students in such activities. Students have rarely the chance to come in contact with authentic scientific work conditions, or to meet in person with real scientists.

There are no such policies and strategies in Cyprus.

Recommendations to stakeholders and policy makers in the view of improving the national curriculum, for promoting students' interest, motivation and engagement in science:

At the policy level, it may be important for national policy makers to:

- perform curricular reform: both acquired and developed key competences should be clear and set at levels appropriate for learners of different ages and stages. Curricula should be flexible and "open" to include other competences that are not currently in the European framework, on one hand, and to include non formal activities and recommendation and encouragements (doubled by real-life examples / activities in the field) to choose for a career in science, on the other hand.

- support teachers: as teachers play the most crucial role in implementing key competences, resources for their continuous professional development should be a priority.

At school level, some changes that could be done are:

- allow time for teachers to develop and deepen their practice: many teachers are used to prioritising teaching which focuses on content in one single subject area. They may need time to change their perceptions on the value of competence-based approaches. They will also need time to develop their own understanding of key competences and to integrate new methods such as project-based learning, and meaningful assessments. New ways of relating with the students will also take time.

- modify learning environments to better support project-based and interdisciplinary learning: to some extent, classroom environments may be fairly easily changed to support collaborative work and research or modified school timetables. But investments in new technologies or remodelled facilities may also be needed over the long term.

As an example, we may add that at this moment, the Polish Core Curriculum has been revised. The national curriculum should be more flexible, giving more opportunities of creativity to the teachers; allow and help multi-disciplinary skills development, especially in the context of natural sciences.

- require a greater financial contribution from the state, to improve laboratories equipment with complete and useful aids;

- support teachers in acquiring the key competences, especially in the application of new technologies in teaching and in continuous professional development.

By highlighting social, political and cultural factors behind science and technology, students can perceive these domains as much more humane and close to their own interests. History and philosophy of science can provide a conceptual context sensitive to the eventuality of scientific and technological achievements. It is important to show that science and technology can be fun for young students. Moreover, constructions or participation in scientific contests, educational projects, and science trips can engage students more actively. Finally, the Greek teachers propose the incorporation of more ICTs and more hands on experimentation in science teaching could enhance students' interest.

The Cyprus recommendations are: the development of new educational material (handbooks, books etc), training teachers on using ICT tool, provide constant and on-site support on ICT tools, provide ready lesson plans to teachers. An interesting idea is the development an online community where teachers will be able to share their thoughts and ideas regarding innovative ways of teaching science education

The Irish educators recommend that number of pupils in classrooms need to be reduced and a complete curriculum that already incorporates different subjects and different teaching methodologies need to be introduced. Given a proper structured programme however, Irish teachers would be able and willing to incorporate SciFun into their classes. A comprehensive teacher training / Professional Development course would also be an asset for teachers as it would instruct them on best practice when incorporating SciFun into their lessons. Trying to make SciFun more accessible and common to learners is also important.

Part 3: Findings from the Questionnaires

This part presents the findings from the Questionnaires, which were applied to 10 teachers from the pre-university system, in each country involved in this project. The subjects that the participating teachers teach, are: Physics, Mathematics, Chemistry, Technological Education, General Science. In Poland, four teachers teach more than one subject, namely: Physics and Chemistry (3 teachers), Physics and Mathematics (1 teacher).

Most of the respondents work in schools where students are 11-15 years old (80%).

The group of pupils that the respondents are working with at a time has various sizes: in Greece, all of the teachers work with medium size classes (20 to 25 students), like in Cyprus, Poland and Ireland. In Romania the classes are generally composed of 30 pupils (30 pupils being the maximum limit allowed by the Law of Education; classes larger than 30 pupils may function only based on a prior approval from the County School Inspectorate). Only in Poland, Ireland and Cyprus 10% of participants stated that the size of the group of pupils they are working with is less than 15 students.

In Poland and Greece most lessons last less than 50 minutes. In Romania, all participants responded that the duration of a typical lesson is 50 minutes, as this is imposed by Law of Education for lower and upper secondary education (kindergarten and occasionally primary education works with shorter durations). The duration of a lesson In Cyprus is 80 minutes (the longest duration of all analysed countries).

The frequency of teaching a subject in a given group of students is according to the national curricula and depend very much on the type of the subject (frequency is subject-related), i.e. Mathematics has more teaching hours allocated in the educational plan than the Technological Education, Civic Education, etc.. In Cyprus 91% of the participants stated that they teach one class per week to the same group of pupils, in Romania and Greece the most teachers have allocated 2 classes per week, while in Ireland 80% of the questioned persons have 4 classes per week.

The most commonly used techniques and teaching methods are: problem solving method, presentations and work in groups (80% of teachers). Narrative and brainstorming, working in pairs, discovering, learning by doing and individual work of students are other indicated method. Debate and controversial debate are less preferred by teachers from Ireland and Greece. No one pointed case study and role play in Poland. All respondents ticked more than one method of teaching.

All teachers answered that the curriculum is not flexible, because teachers are allowed to introduce new topics in their teaching in a percentage which is less than 10% of the total curriculum (this is the so-called “curriculum at teachers’ disposal”).

Most of the teachers admitted they are quite much familiar with mobile devices (GPS, PDAs, Tablet PCs), comics, digital storytelling, film, multimedia, and Web 2.0 technologies. This result shows a good anchoring in the knowledge society and digital era.

Mobile devices are moderately used by Greek teachers; they are used in every class by over 60% teachers from Cyprus and Ireland. 90% of the Romanian teachers use mobile devices in teaching "from time to time" in order to better motivate their students.

Examples of mobile devices, technologies and tools that the respondents stated they use during their classes included computers or tablets, movies, applications/ simulations, Web 2.0 technologies (wiki, blog, youtube, scholaris, Interklasa, phet colorado etc.), projectors, multimedia, Power Point presentations, digital narrations, e-books, movies from edurom (popular educational software in Romania), narrative film, GeoGebra.

Most teachers think that the use of mobile devices (GPS, PDAs, Tablet PCs), comics, digital storytelling, film, multimedia, and Web 2.0 technologies is feasible/suitable for the subject they teach to a moderate extent (respondents from Romania, Greece, Poland) or to a high extent (participants from Cyprus and Ireland).

All the respondents answered positively that they would like to learn more about how to use mobile devices, Web 2.0 technologies and tools for their teaching.

The teachers mentioned various advantages that the use of mobile devices (GPS, PDAs, Tablet PCs), comics, digital storytelling, film, multimedia, and Web 2.0 technologies could bring in their teaching. Most of these advantages are common, as they have been expressed by all participants: make lesson more exciting/interesting, increase motivation, creative process, better student learning and engagement, more effective and participatory lesson, simulation of experiments. The teachers from Ireland stated that the introduction of i-Pads for students meant the end of heavy school bags and smaller storage space needed for students, but most of all, it gave all teachers the opportunity for ICT learning in all classes. The participants from Poland mentioned as advantages saving time (for example: plotting graphs, etc.) and possibility of sharing knowledge between teachers. The Cypriot teachers added the following: students can have access to multiple sources of information and feel comfortable with technology. Moreover, teachers from Greece also mentioned that these devices and techniques could encourage "self-learning" and develop the students' digital skills, while they could also help students to feedback about their progress in the relevant subjects.

The challenges that teachers mentioned concerning the use of mobile devices (GPS, PDAs, Tablet PCs), comics, digital storytelling, film, multimedia, and Web 2.0

technologies in their teaching, relate mostly to the lack of necessary infrastructure (not enough PCs for the students, lack of expertise on the part of teachers, poor internet connection,). Teachers also fear that students may misuse technology and get distracted from the learning objectives or, on the contrary, be passive during the process (Greece). The reluctance of parents (Romania) and how to control and have safe use of personal devices with Internet access (Ireland) are other major problems that could appear in using mobile devices in teaching science.

Finally, the lack of time (incorporating mobile devices in the lesson will be time consuming - Cyprus), the adoption of the curriculum learning activities on the basis of the mobile devices and the fact that some of these tools may make teachers become unnecessary (useless) or may disrupt the teacher-student relationship were also mentioned as challenges.

Most teachers mentioned that it is crucial to educate teachers in using mobile devices (GPS, PDAs, Tablet PCs), comics, digital storytelling, film, multimedia, and Web 2.0 technologies in science education as a method that involves students and enrich lessons, provide fast access to information, in real time (Greece, Romania). These Tools help students learn through 'fun' and increase the love of learning. For example Interactive blackboard, games, Power Point presentations, You-tube and documentaries, GoNoOdle, W5 Science Museum, science Magic field trip or outdoor experiments where things explode (e.g. Volcanos, recommended by Irish teachers in the questionnaires that they filled in) can be used to achieve this goal. The teachers from Poland suggested the organization of training courses within institutions on how to use the digital devices (because many teachers are afraid to work with them) and popularize among the teaching staff the use of modern media. This way, teachers could share teaching practices among them and benefit of constant training opportunities (Cyprus). Also, it would be great to provide these devices to schools for free.

The respondents consider that the Toolkit developed by the SciFUN project must include: case studies, a methodological guide, practical information, access to educational sites, a course-support on teaching methods and examples about how to conduct lessons by using mobile devices. Simulations, digital interactive games, movies, digital library with ideas and applications were also mentioned (Greece). Include funny experiments, set up clubs for science and movies, use TV shows such as The Big Bang Theory to reinforce learning complete the suggestions by teachers were suggestions received from the Irish teachers.

The survey was attended by 29 women and 11 men (Cypriot participants are not included here, as demographic data for them have been not provided) aged between 22-58 years. The largest seniority was 33 years (Poland) and the smallest duration of

service as a teacher, in our transnational sample of participants, was of 1 year (Ireland).

All of the respondents hold a HE diploma (Bachelor degree), most of them have post-university education or performed Master studies. Some of the participating teachers graduated other professional training programmes (except the one for obtaining the diploma in their field of specialisation) in the field of didactic or/and psycho-pedagogical training, namely: Educational management, ICT, Communication skills in the knowledge society, Methodology of teaching Chemistry, Initiation in ICT and utilization of AeL, Didactics and Methodology of teaching Physics, Training to become member of the Body of Experts in Education, “Another chance” training programme.

Part 4: Findings from the Focus Group

This part presents the findings from the Focus Group.

The profile of the respondent was not possible to be described holistically, for all participants, as Greece and Cyprus din not provide data on their profile, and Poland and Ireland did not include gender statistics in their national reports.

The Focus Group was achieved with 5 persons (stakeholders, educators and teachers who are involved or connected with science education), in each partner country.

The purpose of the Focus Group was to identify the specific needs of students and educators on how to make science learning fun, more attractive and interesting, how to better motivate and engage students. The results of the Focus Groups will help presenting recommendations that will be useful for subsequent project outputs development.

The duration of each Focus Group was of approximately 1 hour.

In total 25 teachers of Mathematics, Chemistry, Physics and Biology at Primary School, Middle School and High School / National Colleges have attended the Focus Groups organised in all partner countries.

All of the respondents have agreed that the pupils aged 9-15 are in general attracted by sciences, but especially by the practical part of sciences – meaning not necessarily only experiments but also simulation of such experiments. This is due to the fact that pupils are acquainted with mobile devices and modern technologies and they have good ICT skills.

The attitude of students on sciences depends on the class profile, type of institution (secondary school, industrial, vocational, etc.) and sometimes their opinion could change from gymnasium to high school and vice versa (Romania, Greece). Those from technical-vocational education are more oriented towards science than the ones from humanistic educational branches. Educators seem to agree that under certain conditions all students could show interest. For example if they visit a science museum, if the teacher uses technology to show students simulations or do experiments in a lab - but this is strongly depending on the teacher approach and behaviour (Ireland). If the lesson is teacher-centred and students do not have the opportunity to explore, test, verify and experiment, then they will most probably develop a negative stance towards science education (Cyprus).

The most attractive field seem to be the practical one, i.e. Physics, Biology, Chemistry or other subjects related with violent natural phenomena (earthquakes, volcanoes, explosions, black holes) such as Astronomy, Geology. Mathematics seems to be too theoretical, in the opinion of students aged 9-15 years from Poland.

The opinions upon the gender differences regarding the interest and motivation for science education are quite spread: in Cyprus and Ireland there is no gender difference on the interest, motivation and engagement in science education, due to the fact that students are still very young to indicate a clear preference, while in Poland and Romania professional experience of respondents shows that, in general, girls are more preoccupied by school, are accurate, they carefully carry out their task and have a greater patience. Gender differences do seem to exist but they are dependent on the subject matter. For example, girls seem more active in Chemistry and Biology (more useful to professions socially reserved for girls, as nurses) while boys are more active in Computer Science (Greece). The best indicator of gender differences in relation to the interests and motivation of science education is the review of the participants of "science interests groups" or "science circles". In the case of Physics, most of them are boys (Poland).

Regarding the school performance and results, all the respondents stated that students generally perform well in science. In some cases, students performed better in science than other subjects which include more theoretical activities rather than experiments (Cyprus). Some of the students are doing very well in all areas, because they simply are very talented. But of course, there are students who are doing quite good only at science because of their predisposition (Poland). The teachers from Greece think that students find science subjects more difficult than others. This is why they also lose their interest, especially when serious mathematics comes into play.

Even the number of hours allocated to sciences within the specific curricula in Romania decreased in recent years, the importance of sciences at the national exams remains high. Compared to other disciplines, at classes with Mathematic-Informatics or Natural Sciences profiles, the graduation rate at Baccalaureate is a very high one (95-98%). The students that have performed better at Mathematics have performed better at Chemistry or Physics, too.

According to all participants, a major factor in stimulating students' motivation to learn is the teacher and his attitude, commitment. If lessons are interesting, and the teacher leads the students in an understandable, encouraging way, with passion, then students engage more often and deeper, and their scores are getting better. A good teacher can make a student love science forever, or on the contrary, to hate it all lifelong (Greece).

Another very important factor is the example / attitude in the family. Sometimes parents justify the failures of their children's education because they did not like science too, and they project their own experience onto their children. Other times, parents encourage their children to work hard in this field, in order to avoid the

failures that happened to them years before. It is noted that better educated parents, foster better performance of children. Sometimes, however, excessive ambitions and hopes placed on children can even "paralyze" and weaken children's motivation and later on, the children's results (Poland).

Other factors are: motivation, social environment, a basic background of knowledge, the classroom equipment. School environment plays a role as well. In some schools the principals are very active in motivating teachers and students towards science by organizing visits to science museums, acquiring laboratory equipment for the school, or encouraging participation in science fairs and scientific contests (Greece). It should be noted that the exam system in Greece is very brutal and suspends all interest and fun from education.

Factors are complex and complementary (Romania). For example, Mathematics, involves more exercise and connections which help the student to synthesize study materials at other disciplines.

Many international studies have shown that there are no significant differences between boys and girls in this field, especially during childhood. Subsequent differences often arise from profiling ones interests and investing time and effort in the selected area – girls often choose humanities or medicine, while boys go for science, engineering – even though it seems to be stereotypical, but this is still true in many cases (Poland). The interest or the lack of interest for sciences it is linked to the pupils' plans for the future, to their options for a future profession (Romania).

In general girls tend to perform better than boys in all the subjects, due to the gap in the psychological maturity of boys and girls (Greece). At high school, boys are usually more often distracted by the surrounding challenges and they cannot easily concentrate on their studies. However, at a certain age boys' and girls' attitude and motivation for learning is at the same level.

The solution proposed by Greek teachers is to liberate science education from the needs and constraints of the exams, because it kills the interest. Teacher could try to inspire students to work for great achievements and show them how their actions can result in important, meaningful changes for society. According to participants in the Focus Groups, it should be taken into account that society and the labour market are in a constant change and that students will have to be able to adapt in a constantly changing social and working environment.

Difficulties and obstacles

One of the difficulties that a teacher could be confronted with in teaching sciences in Romania is that the number of pupils in the class is quite high (25-32 pupils) and each pupil has his/her own rhythm of knowledge assimilation. Overcoming this disadvantage depends on the competence of the educator and his/her willingness to

work overtime. Classrooms are often too small to conduct classes in a diverse and interesting way. There is no possibility of arranging different work zones – for example: theoretical, experimental, common. Some schools may have other infrastructure problems (no heating for example) (Greece).

Another obstacle is the lack of equipment necessary in the science laboratories. This problem is common in Cyprus, Romania and Poland. If a school does not have the proper infrastructure and properly educational materials for science education, the teacher will have to teach the lesson based on theory, which will have a negative impact on students' stance towards science education. A good way to overcome these challenges would be to try incorporating more of ICT tools in science teaching and try to use different applications (Cyprus). The Ministry of Education should increase the number of hours dedicated to natural science education; decide to lower the limit of students per class; financially help the schools to equip the laboratories and classrooms (Poland, Romania). In opposition, in Greece, if a school follows the necessary administrative procedures, it can acquire a lot of different kinds of equipment. Recently the Ministry of Education gave schools the opportunity to claim robotics kits and 3D printers, but they had to provide a detailed report on how they would use them and prove that there is trained staffs in school to use these devices. The problem is that many times teachers do not have the motivation, the time and the necessary training to use the equipment given.

In Cyprus there is generally a lack of specialised teachers. Often, natural science (Chemistry, Geography, Biology – rarely Physics) is taught by the same teacher who focuses mainly on his/her field, not paying enough attention to the complexity and interrelationships between different topics. It is very important that teachers should be competent and experienced. It is very important to get extra qualifications, learn new methods and techniques all the time (LLL) (Poland). Many teachers, however, still believe that their role is only to transfer knowledge. Some teachers are bored or cannot follow the latest developments or cannot use computers (especially in older ages) (Greece).

The socio-economic background may play a significant role; students from poorer districts may have difficulties in learning science (Poland). In rural areas where students may start working and earn money at an early age, they feel independent and think they do not need school-education or university to have a good life (Greece).

School problems sometimes arise with the overall children health problems (dyslexia, chronic illnesses, intense pharmacology and prolonged absence) as the teachers from Poland have mentioned. The solution is private additional classes with the pupils having learning disabilities.

Another difficulty identified by Greek teachers was the low flexibility of Curriculum; it does not allow teachers to undertake initiatives that could enhance students' interest and motivation (they are usually time-consuming). A problem that was frequently cited is the lack of unity between different scientific school subjects or school levels. There is a fragmentation of knowledge between the separate scientific school subjects that does not help students understand the world around them and how they fit into it.

To avoid or minimize impact of these difficulties, attention should be given to help teachers through constant trainings, providing them interesting materials to work with, facilitate communication between each other to interchange experience and ideas. Participation of teachers in educational projects co-financed from EU funds is often used and brings very good results. Trainings in such projects and postgraduate studies help teachers to improve their working methods and a lot of the equipment was possible to be bought thanks to such projects (Poland).

The most known examples of mobile devices (GPS, PDAs, and Tablet PCs), comics, digital storytelling, film, multimedia, and Web 2.0 technologies which are useful in teaching sciences are: Tablets, Ipads, Chromebooks, Smartphones, Interactive white/black boards, Apps, Games, Ed-modo, Kahoot, Scotkrative, Prezi, YouTube, TED talks, social media e.g. Facebook, Pinterest (Ireland), Crocodile kid and Virtual Lab, software: Algodo and Mindcraft (Cyprus). Simulations such as "Phet Colorado" and documentaries concerning the History of Science (like those of BBC) are great to use in science classes, as it has been remarked by the teachers from Greece. The respondents from Poland pointed out the following services and applications: Padlet, Ipuzzles, e-podręczniki, GeoGebra, Scratch, Peartrees, Khan Academy, Leap Motion, Moodle, Twiddle, GoFormative, Glassfic, e-books and video of experiments.

The use of ICT elements when working with students, make the classes more attractive and inspiring, funnier. To be able to use mobile devices teachers need suitable training upon their use and software adequate to the discipline they teach.

The problem consists sometimes in the too small number of good-quality applications and other materials (such as electronic versions of textbooks). All interviewed teachers were very interested to learn more about how to use mobile devices (GPS, PDAs, Tablet PCs), comics, digital storytelling, film, multimedia, and Web 2.0 technologies in science education. However, they see a risk in using these, if pupils are not supervised and the use of these devices is not limited, controlled, monitored (i.e. children may access information inappropriate to their age, may use in a wrong way the software and knowledge, may understand in a distorted way certain concepts and terms, may spend too much time with these devices to the detriment of effective learning, etc.).

The most convenient digital tools preferred by Poland students were smartphones, because they are offering a wider and wider spectrum of possibilities (GPS, camcorder, built in sensors etc), but using the offline applications; nowadays, most of the students own such devices. According to the existing Greek legislation, students are not allowed to use cell phones into the classroom. Students like using tablets and PCs, but it is more difficult for the teacher to control what the students are doing with them while teaching.

In addition to the above devices and tools, for motivating pupils to learn science teachers declared that they also use: projects, interdisciplinary lessons, study visits and trips (in companies and factories, museums, etc.), outdoor activities. Active Learning involves students directly and actively in the learning process. Students are involved in all stages of planning, design, execution and evaluation (Ireland). Students are so tired of sitting in the classroom all day long, listening to lectures that any kind of action and different activity becomes really exciting (like doing experiments and constructing things with their hands) (Greece).

The science teachers get advice from peers and especially from ICT and Informatics teachers. Sometimes even the pupils provide good inputs to teachers regarding the use of mobile devices, as they are up-to-date in this field, good practitioners and "connected" users (Romania). In Greece there are Laboratory Centers for Natural Sciences (EKFE), responsible to train teachers in doing experiments. There are also school advisors in charge with giving ideas about how to improve teaching of each subject. Teachers also look for relevant information by collaborating with the university staff.

A way to encourage science education at pupils aged 9-15 years is to organize and get them involved in scientific contests and competitions (i.e. in Romania Chemistry and the Computer, where pupils design science websites, create PPTs, elaborate drawings on science topics), The Young Scientist national competition, Sci-fest competition and exhibition, "I'm a scientist get me out of here", W5 science museum, Bodaborg-crystal maze and 360 YouTube, 3-D models relating science to real life, Working Scientist visiting the classroom (Ireland). An important role is played in Poland by the so-called "Days of open doors" – the annual school promotion activities to encourage the candidates (and their parents) to choose this particular school. During these activities students, under the guidance of teachers, prepare scientific demonstrations, highlights science and fun facts, puzzles that should encourage future students to make the choice.

Participants in the Focus Groups stated that they find information about modern teaching methods mainly from the Internet, conferences, specialty and methodological training courses, specialty books, pedagogical meetings of teachers, methodological committees in schools, national contests attended with their pupils, non-formal meetings with peers. There are also various training programs and platforms for teachers such as e-twinning which provide invaluable resources for teaching.

When asked about, teachers declared that their schools understand, in generally, the importance of science in the life of the mankind. In most schools from Poland, teachers do aptitude tests and thus determine which students can be further motivated. Sometimes, the fact that school recognizes the need to engage students in science education depend, like in Greece, on the principals of the schools and on if they have an interest for these subjects.

In terms of plans and activities to promote sciences as a school, all participants have mentioned the science contests organized for pupils (well received by pupils and highly motivating), school Olympics and the portfolios prepared per discipline (Romania), science picnics, science fairs, festivals, scientific conferences (Greece, Poland). However, it must be admitted that most of the Greek schools do not make systematic efforts for promoting science education at school level. In keeping up the pace with international developments in science education, the plan in Ireland is to allow enough time for active student engagement in learning experiences that will enable the development of science process skills, leading to a better understanding of the underlying science concepts.

Regarding how does the Ministry of Education support science education, one can notice a different attitude among the analysed countries. In Greece, the Ministry shows a great interest: it created a special institution - The Laboratory Centers for Natural Sciences (EKFE) - that is of great help in that sense, it organizes various in-service training courses for science teachers, it provides schools with the necessary digital equipment and infrastructure, it renews science curricula to become more attractive and it has frequently updated school textbooks and digital resources to provide teachers with appropriate learning materials for facilitating students' learning. The Ministry of National Education from Poland supports projects promoting science at a financial and social level (TV campaigns, etc.). There are many opportunities to apply for funding, both nationally and through EU financial mechanisms (but the procedures are complicated). In Ireland, the current Minister believes that smaller class sizes mean teachers having a greater chance to change the way they teach and giving each child that individual attention. The Romanian Ministry should support more science education (the laboratory equipments are old, rusty,

with malfunctions). New software (i.e. LabView) and high speed Internet, functional in real time would be necessary.

In Romania, parents and society provide support only occasionally (it varies from case to case: some parents respond promptly to school request, other refuse). This reaction and involvement depends on certain factors: parents' educational level, culture, openness towards school (some parents even forbid participation of their children in school competitions or spare the child from going to an extra-curricular activity in school if raining). Working with parents is harder than working with pupils, it is harder to motivate parents – that's why there is a need for "a school for parents". Involving parents in the educational process is essential. It is quite difficult to engage parents, said the teachers from Greece. Some of them are very reluctant or very busy to participate in school life. In many schools from Poland and Greece, teachers and pupils prepare dedicated activities for parents or even do parent-children science activities. The Irish teachers mentioned that reading starts at home and young people who read for pleasure tend to achieve higher grades in all subject areas.

It is necessary that media and parents engage constructively in education. If ways to better involve parents and society in supporting science education and science teachers could be provided, this could be of great help and could foster the obtaining of higher performances in teaching science.

All participants expressed the view that they do their best so as to try to inspire students and make science learning fun and interesting for them.

Teachers from Greece believe that the unification of all separate scientific disciplines into a common school subject would be very effective. They also believe that it would be very important to show how contemporary science works. Such an approach would prepare students for a constantly changing world and the contemporary face of science. The curricula should have subjects that mix humanities with sciences to help students understand how everything is part of the same world.

The results obtained by pupils in sciences competition should be mediatised and the pupils should be rewarded with a medal / diploma / cup even at a local stage. These will increase children's motivation and engagement in science education (Romania).

Conclusions and Recommendations

Students in all analysed countries seem to have a positive attitude towards science and technology and their role for society. This curiosity and interest could deteriorate if teachers are not able to conduct the lesson in a funny and attractive way. Students hold many stereotypes about what a scientist is and what the common scientists' attitudes are.

In some countries (Greece, Romania) the education policies and teaching strategies correspond to a traditional view about science learning. The science curricula have to have a structure which create interest, engagement and motivation for students. At this time the curriculum is not flexible (teachers can introduce new topics less than 10%).

Teachers are interested in using mobile devices in classroom in order to stimulate and motivate the learning activities of their students. They appreciate that the benefits of using them in science education are: increasing student's interest for sciences, allowing rapid documentation, developing imagination, better understanding of the phenomena, better retention of the taught concepts, substitution of the lack of laboratory equipment.

All students like to use of technology, simulations, applications and digital material such as movies. They also like doing experiments or constructing and participating in project-based and inquiry based learning activities. These activities help them rediscover the "magic" and wander of science and they can be much more effective in motivating and stimulating the students' interest in science and science education in particular. It is also important that these activities are much more funny than regular teaching.

From our research we can clearly see that in all analysed countries there is a willingness to try utilizing SciFun in classes due to the belief that it will enrich the learner's experience. There is currently no training for teachers in using fun science lessons for teaching classes. Given a proper structured programme, teachers would be able and willing to incorporate SciFun into their classes.

A comprehensive teacher training / Professional Development course would also be an asset for teachers as it would instruct them on best practice when incorporating SciFun into their lessons.

Another important route for the project, proposed by the Irish teachers, would be to relate science to real life, for example inviting a working scientist to visit the classroom.

Recommendations for the Toolkit

The teachers that have participated in our field research opined that the SciFUN Toolkit should:

- be written in simple and coherent language, in order to be accessible to more persons belonging to different age categories;
- have both a written and electronic form in order to be easily used and distributed;
- contain examples of good practices regarding the using of mobile devices (GPS, PDAs, Tablet PCs), comics, digital storytelling, film, multimedia, and Web 2.0 to different learning styles.
- contain examples of science lessons and indoor and outdoor activities, based on the use of mobile devices and Web2.0 technologies.