Research Paper E-ISSN NO : 2455-295X | VOLUME : 3 | ISSUE : 12 | DEC 2017

HOW TO DEVELOP ENGAGING SCIENCE EDUCATION ACTIVITIES: A CASE STUDY IN ROMANIA

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ABSTRACT

The paper shows results obtained from a qualitative research implemented in Romania by the research team of the University of Piteşti involved in the Erasmus+ Strategic Partnership project "SciFUN: Making Learning Science Fun". The purpose of this research was to obtain valid inputs on how science lessons should be designed and what they should contain thus to become more appealing to students, to raise students' interest. The researched aimed at collecting realistic opinions upon the research topics (designing learning activities to enhance (1) students' intrinsic and extrinsic motivation and achievement in science education; (2) their competence and efficacy beliefs; (3) their social interaction and motivation) from teachers and educationalists. The research was achieved in July – September 2016, through Literature Review and Focus Group organized with 5 science teachers who are involved or connected to science education and teach to students aged 9 to 15. The mains results from the Literature Review have been synthesized as practical guidelines-tips for teachers and samples of innovative teaching activities. The Focus Group revealed which are the motivational disciplines for students, the activities relevant to the needs and settings of students, teachers and schools and some recommendations for getting students closer to the mysteries of world and life. The research concluded that outdoor activities and experimental lessons are preferred by students instead of theoretical and traditional ones, games and competitions can make lessons more attractive and motivational and that ICT and Web 2.0 technologies could replace the lack of laboratory facilities, providing high-tech experiments.

Keywords: Science Education; Motivation; Web2.0 Technologies.

1. Introduction

The paper presents results and findings from a qualitative research in Romania on how to design engaging and motivating science education activities. The research was developed within the project "SciFUN: Making Learning Science Fun", with reference number 2015-1-RO01-KA201-015016, financed by the Erasmus+ Programme of the European Union.

The SciFUN project aims to make learning science fun and relevant to students' contexts. This approach proposes a new conceptualization of science on the premise that science is socially structured as much as science influences the structure of society (Russell, 10003; Burke et al., 2012; E. Mendelsohn, et al., 2012) and that a good education requires education in a diverse environment (OECD, 2006).

According to Eurydice report (2011), *"international student achievement studies demonstrate a clear link between enjoyment of learning science and science achievement"*. PISA 2015 also reinforces that *"Because knowledge and understanding of science is useful well beyond the work of scientists and is necessary for full participation in a world shaped by science-based technology, school science should be promoted more positively – perhaps as a "springboard" to new sources of interest and enjoyment."* Sjøberg and Schreiner (2010) view positive attitudes towards science and technology as important learning goals in themselves.

Reform documents around the world urge for an approach to science education that addresses the need for improving and sustaining educational access (UNESCO, 2015), and participation for non-mainstream youth and differentiated groups of students.

2. Materials and Methods

We implemented a qualitative research that consisted in a combination of desk-based and field-based approaches. In Romania the research was implemented between July and September 2016. The research was implemented in all SciFUN project countries (Romania, Cyprus, Greece, Poland and Ireland).

The hypothesis in our research was that teachers can increase their students' involvement and motivation for science education through the innovative use of ICT and Web2.0 technology-based engaging activities. With this paper we aim to document this hypothesis through the findings from the literature study and opinions of teachers participating in the Focus Groups.

We were guided by the following research questions: *What contemporary research shows regarding students' motivation in science education? How to enhance the quality of teaching science and promote students interest about science education? What guidelines and ideas for teachers can be innovative and connect science education with real life issues?*

The desk research was achieved through Literature

Review and the field research through Focus Group. Research framework and tools have been designed by the project consortium under the scientific coordination of the University of Piteşti.

Based on a Literature Review, we first synthesized a set of practical guidelines-tips and learning design principles to develop engaging science education activities and units. Subsequently, we elaborated samples of innovative teaching activities. The last phase of our research consisted in organizing a Focus Group with 5 science teachers who are involved or connected to science education and teach to students aged 9 to 15, in order to expand the approach and get more in depth and relevant results. Through the Focus Group we also aimed to ensure that the educational content to be designed by SciFUN project is relevant to the needs and settings of real students, teachers, and schools; and that a significant number of teachers will have ownership of the project's products.

During the Literature Review we researched the national available data (policy documents, national strategies, books, scientific articles, surveys, reports, projects, guides, statistics, analyses, official web pages of representative institutions and authorities in the area, etc.) in order to identify relevant information about how to develop engaging science education activities for four envisaged areas, namely: Science & Technology Education; Environmental Education; Multicultural and Civic Education; Informal Learning. A special emphasis was granted to Science Education.

We organized the Focus Group with 5 female teachers of Physics, Geography, Biology, Chemistry and Mathematics. The aim was to verify the relevance of Literature Review findings and to get the participants' input regarding: innovative teaching ideas/activities; ways to improve science teaching and learning; information and content that participants might need to include in the "Making Learning Science Fun - SciFUN" Toolkit.

Before the Focus Group session, all participants completed a short questionnaire for providing data about their professional profile: they teach sciences to students in different grades, namely 3 at lower secondary school level (gymnasium) and 2 at upper secondary school level (high school). In terms of teaching experience or school-related environment experience, our participants have between 6 and 26 years of experience. The average is 20.2 years of experience.

The duration of the Focus Group session was of approximately one hour. Participants signed an informed consent. The Focus Group has been video recorded and the transcript has been realized afterwards. Prior to this Focus Group the participants have been provided with a material containing activities aiming to enhance the motivation and engagement of students in science education (these activities have been designed by project team based on the Literature Review).

3. Results and discussions

3.1. Results from Literature Review

The Literature Review allowed us to formulate the following practical guidelines-tips, learning design principles and recommendations that are addressed to teachers, educators, trainers and other relevant stakeholders when they develop engaging educational activities and units which to motivate students in science education:

- Review the curriculum and the official documents and policies and propose the development of creativity *(Inquiry Based Science Education)* and of the social and affective factors in the learning and (self-) evaluation process. Students see themselves as active actors and this nurture their motivation for learning.
- Encourage the students (as future adults and citizens) to see themselves as part of the environment where they live, emphasizing the role and the place of the science in this environment. It is important for the children to understand and learn the concepts being taught and their presence in their daily life: the chemical substances are everywhere (in the stars, in all living beings, in our food), the physics phenomena move everything (the rain, the snow, a ball or a ship floating, etc)
- Promote a more collaborative education giving students a public (virtual) space to interact and collaborate with each other using social media, blogs, video sharing sites, mobile devices, comics, digital storytelling, multimedia, application platforms (eyeOS) and Web 2.0 technologies, in general.
- Develop the children's technology skills to successfully learn science and to join later, as adults, a technologically advanced society and work environment. A special attention should be paid to avoid any kind of discrimination among students (having or not having the latest devices, helping all pupils to have good technology skills).
- Incorporate funny games in the curricula (playing games, learning songs, watching videos online, etc.) for getting the desired results and for providing funny learning. Thus, the teacher can valorize the children's passion to play games on computers, smart phones, tablets and other mobile technologies.
- Incorporate in the teaching process informal and authentic learning, outdoor activities and the collaboration with scientists.
- Organize activities in science and research centers, using those environments where the experiment is actually performed, as "living laboratories". The students interact with professionals and develop their verbal reasoning skills.

- Encourage students to plan and fulfill inquiry outdoor activities in a team, coaching them to learn to work collaboratively. Working with others is an important skill for them to learn for school or for work later in life. Children externalize, share and develop their thinking and their ability to reason.
- Cooperate with the local and national cultural actors and institutions (museums, cultural centers, etc) to propose activities connecting the scientific events and the school curriculum.
- Develop useful skills and behaviors as: taking care of own health and of the others, protecting the environment, etc.

In addition to the above recommendations, the Literature Review helped us designing a set of innovative teaching activities for motivating and engaging students in science education. One example is rendered in *Table 1* below. These activities are innovative through the approach, techniques, methods, content and ICT & Web2.0 technologies used.

Table 1: Sample of science teaching activity to better engage and motivate students

Title of the activity	Breaking distance in different conditions
Organisation of the group of pupils	Pupils perform the allocated tasks as a whole class
Duration of the activity	50 minutes
Location of the activity	Outdoor
Brief description of the activity	The lesson takes place outdoor. The teacher announces the topic of the lesson and its objectives. The teacher invites a professional biker in order to facilitate the following task. Pupils have to find out how the different types of conditions affect the breaking distance. With the GPS of the bike, the pupils will record the speed of the bike. The biker will perform on dry surface, wet surface, slippery surface and sandy surface. Then, the pupils will measure the breaking distance in each case. After performing the practical task, the pupils will download the GPS records on their tablets and combine them with the measurements. Using Microsoft Office Excel on the tablets, they have to make diagrams of the influence the surface has on the breaking distance.
Evaluation & assessment of the learning outcomes	This activity will be evaluated through a practical safety guide for bikers in case of different meteorological conditions.
Additional support & information for teachers	In order to perform this activity, the pupils need a GPS, measurement tools and tablets (with Internet access and Microsoft Office Excel).

3.2. Results from Focus Group

During the icebreaking, the facilitator gave the participants an easy task: they were asked to *rank* (on a scale from 1 to 10) *different sciences* (suitable for pre-university education) in terms of their motivational value and attractiveness for students. The obtained scores showed that the most attractive science is ICT (10) followed by Geography (9) and Biology (8), while the less attractive seems to be Civic Education (6). Physics and Mathematics got each a score of 7 points.

When asked which of the *sample innovative activities* presented to them from the Literature Review *they consider relevant* to the needs and settings of real students, teachers and schools and if they would like to change something in these activities, the participants did not refer to certain activities exactly, but they generally discussed about them.

According to the discussions, it was emphasized that

outdoor activities are preferred by kids. They like to go in the forest and learn the Geographical phenomena at the scene. Our participants stated that experimental lessons are considered to be very good for a better understanding of the concepts. It also helps the students to remember the phenomena for a long time. It definitely suggests the fact that the students focus, deliberately or not, on the practical side of the learning process. It is easier for them to understand and keep in their mind the information if they associate the theory with the practical facts.

When it is about the content of the lesson, it should be clear and rendered in simple terms, in an attractive format. Even if the new concepts they have to study seem to be difficult and complicated, if they are rendered in a structured and logical way, they are by far simplified. Moreover, this kind of approach helps the teachers to avoid the loss of interest of their students.

As weaknesses of teaching outdoors, the participants mentioned the necessity of approval from the principal of the school and the higher amount of time that lesson planning takes. Moreover, the participants highlighted that the curricula is too tight and rigid, which obviously is in totally contradiction with the students' needs and expectations. It also has (as a cause) the complicated terminology and, as a consequence, the student loses his/her interest.

To the question *"How teachers can make teaching science fun to their students, how they implement innovative teaching activities?",* the participants in the Focus Groups opined that games on science themes could attract students to learn science, as well as competitions with prizes - others than academic contests (the so called Science Olympiads), namely the national contests like *Earth Sciences* or *You know, You can, You win!*

In relation to *factors that could attract and motivate students for science education*, the participants to the Focus Group have also emphasized on the role of a good communication between teacher and students. An informal way to conduct the lesson represents other methods throughout the teacher can break the so-called wall between him/ her and the students. Outdoor activities, games, experimental lessons and an approach of 'more practice - less theory', visits to museums and trips represent unconventional but engaging ways to take a class. Leaving the classroom and setting nature and the outdoor environment as the learning framework can make the students forget about the restraints of a traditional class and help them gather the information faster and easily. They help the students become more close and familiar both with their educators and the new concepts they have to learn. Moreover, a pleasant environment makes the students pay more attention to what they are taught and to deeply understand the phenomena because, in the case of the sciences, we talk not only about theory but also about practical, experimental aspects.

Our participants consider that the *topics and/ or the activities the students mostly prefer in science education* are those connected to the environment around them. The Universe is a favourite topic regarding Geography, the Anatomy is important to know the human body. We should add the topics related to the daily life and cross-curricular lessons. It is important to observe the tendency to prefer topics which are directly connected to the human life, activities and environment. The students need to know how this Universe functions, how we can help it in order to avoid destroying our area. Thus, practical topics instead theoretical ones should be chosen and designed in an attractive way in order to get the students closer to the mysteries of world and life.

The *practical guidelines, tips and recommendation* the participants in the Focus Group have suggested to educators, teachers and trainers in order *to make their science teaching more interesting and motivating for students,* highlight the importance of arising curiosity, changing the old didactic strategy with a new and innovative one (e. g. starting the lessons with a story or question), communicating with the students by means of modern socializing tools, using fun exercises and applications. The last idea highlights the consequence of living in a digital society and the importance that ICT and Web 2.0 technologies have in the learning process. Teaching should be adapted to the students' needs and points of interest and the information should be provided by technological means, which are more attractive for nowadays students. It prevents the loss of interest and also facilitates learning.

When asked about *how we can improve science-learning opportunities for all students*, both in and out of school, the participants highlighted the necessity of improving the laboratory facilities in order to undergo more and more experiments. Again, it is pointed out the importance of the practical side of learning and how students can apply in the daily life all the theory they are provided during the lessons.

Living in a high-tech society involves the importance of using more technology and experimental electronic platforms, because the students have the necessary computing science abilities. Thus, teachers should focus on using the multimedia tools and online platforms in order to undergo experiments or to provide examples based on the science topics they taught. As the participants also noticed before, this kind of approach facilitates learning, helping the students not only to memorize the phenomenon, but also to deeply understand it. This issue leads to the possibility of applying what they learn in the daily life – leading thus to what we call getting competence.

Unfortunately, the schools in the rural environment provide poor facilities and teachers have to use their personal laptops and tools in order to facilitate science learning and avoid the loss of interest in the case of their students.

As emphasized by participants, the *skills and resources needed by teachers in order to engage in ambitious and*

efficient science teaching contain the ability of a good communication with students. For them, it is not always enough to present the lesson. The students have to be motivated and encouraged in order to involve in projects and different activities. It is also important to like kids and respect them. Moreover, good didactic and scientific competences are quite necessary, as a minimum of resources such and laboratories too.

In relation to *"How do we design science learning environments and curriculum materials that support students from a variety of backgrounds and with diverse interests?"*, we notice that the opinions of the teachers taking part in the Focus Group are quite differ from teacher to teacher and that many innovative ideas are definitely needed, like described in the following lines.

Firstly, the course books are old and quite unattractive. They can be seen as a cause of the loss of interest and attention of the students. Thus, they should be replaced with modern and innovative tools which catch the attention of the students and respond to their real needs and expectations. Secondly, electronic format materials like the books for primary school would be desirable. They represent the first step in replacing the traditional way of teaching science and the bridge to the ICT and Web 2.0 technologies. Moreover, making maps with the students (as a didactic material) make them very proud and involve them directly in the learning-teaching process. In addition, teachers use CDs from SIVECO, with different types of interactive lessons for Biology, Chemistry and Physics (they are very attractive for students because of the way they are designed). Finally, it seems that students are good at graphics and mathematical functions due to the use of the soft Geogebra, as stated by one of the teachers who participated in the Focus Group. This highlights the fact that modern technologies facilitate learning, not only because they help the teacher make the lessons more interesting, but also they provide the students with real possibilities to cross beyond the theoretical limits and improve their competences in their field of interest.

A key point in the Focus Group was *the usefulness of new educational technologies in the learning-teaching process*, how ICT and Web 2.0 technologies for science learning could support the understanding of science concepts, laws and principles and the achievement of the science learning outcomes.

All the participants agreed that the new technologies have a major role in science teaching. They facilitate making the lessons more attractive and provide a good understanding of the taught concepts. They are useful in order to see things which, during a traditional class, one cannot see (e.g. the intern structure of an animal). From an ethical point of view, they are a way of avoiding, for example, dissections. They also can replace the lack of laboratory equipment and save time during the lessons.

Also, our participants noted some weaknesses of using digital tools and technologies or consequences which should be prevented. Preparing the lessons requires a higher consumption of time. Educators should take care not to replace the teacher with a computer because it is always necessary to supervise the students all the time they use the computer or other modern tools.

When *asked how teachers can link the science learning opportunities and results provided in and/or by school to lifelong access to science* and how sustainable school science education is for the development of further science education/career, the participants highlighted the importance of each science in part. To begin with, students admitted that they liked Geography because they knew how to orient, how to choose an itinerary for a trip and how a cave was formed. Furthermore, Mathematics helps people to think logically, to make connections. It also is important for the national exams (this is also an option belonging to the students). Last but not the least, Physics definitely help us in everyday life.

The participants suggested a variety of ideas on *how teachers can stimulate students' appetite for science*. They can organize competitions with awards, or a Science festival. Another useful idea is to organize meetings with a science careers, innovators or giving examples of people who have a good financially life because of science. Apart from this, students are very active at this age (9 to15 years) and they definitely need clear and diverse activities, which do not require much time.

According to the participants in the Focus Group, the *"Making Learning Science Fun- SciFUN Toolkit"* (SciFUN Toolkit) should include models of different types of lessons (how one should teach and evaluate). Also, new didactic strategies used in other countries are important and should be included in the Toolkit, because they provide examples of how education works in other countries and could represent a source of inspiration for the Romanian educators as well. The SciFUN Toolkit should be available both in a printed and electronic version, maybe on a platform specially designed for teachers. In this way, every teacher can easily access the Toolkit. Other useful components of the Toolkit should be practical examples of how an experimental lesson of Physics is led, how a soft on Mathematics concepts is used, or practical examples of Chemistry experiments. These components are in total agreement with the students' needs and expectations, as they are looking forward to the practical side of learning and the applicability in the daily life of what they are taught.

In the end, the participants pointed out several aspects that were not reached during the Focus Group. They underlined that it is important to give more attention to science and to restructure the existing curricula. Increasing the number of science classes per week in order to have a balance between all disciplines would be crucial for getting students more engaged and obtaining higher school performances in sciences (nowadays, students have 1 Biology class/ week and 5 Romanian language classes/ week). Moreover, parents should involve more in the education of their children and teacher should have better salaries.

3.3. Discussions

By sharing results from our qualitative research and providing sample activities, in this paper we have attempted to highlight the importance of developing engaging science education activities to increase students' motivation and interest. There is good convergence in that with findings of Cheung (2017) that states "*The strongest factor affecting students' individual interest in school science lessons was science self-concept […]. Teachers should pay special attention to the association between academic self-concept and interest if they want to motivate students to learn science at school"*. The hypothesis is also validated in a paper of Hellgren & Lindberg (2017) that claim that *"Students' motivation for science declines over the early teenage years, and students often find school science difficult and irrelevant to their everyday lives."* and questions *"whether creating opportunities to connect school science to authentic science can have positive effects on student motivation".* Their findings suggest that *"that the authentic experience can arrest some aspects of the decline in motivation for science in the teenage years".*

As shown above, engagement in science education is a topic largely approached, in various studies. Quality of teaching relies, among other factors, on engagement and motivation of students. Osborn et al. (2003) state that *"The literature itself points to the crucial importance of gender and the quality of teaching. Given the importance of the latter we argue that there is a greater need for research to identify those aspects of science teaching that make school science engaging for pupils."*

Students are increasingly interested of digital tools and technologies and expect more impactful and inter-active learning environments. This is also supported by the findings of Li (2010), who, in a study examining students' learning experiences through digital game building and playing, emphasized that *"There was also evidence that students increased their understanding of the subject matter in question (mathematics, science and technology) and enhanced their general problem-solving abilities through the process".*

Teachers and course designers need to consider using Web2.0 technologies in order to successfully engage and motivate theirs students in science education, as also sustained by many studies in the field: Chimo (2012) shows that *"The Web2.0 programs appear to have a positive effect on student engagement and research skills"*, Koh & Chwee (2009) point out that *"The use of Web 2.0 technologies could bring about a fundamental shift in pedagogy and assessment towards a participatory learning approach that promotes a deeper and more engaged understanding of science"* and Ellis (2013) argues that *"It is advantageous, as an educator, to use these Web 2.0 technologies in the classroom as designing lessons and learning around these areas will spark the students' interests."*

Increasing students' interest for sciences can be achieved through innovative didactics and utilization of of digital tools (including online platforms), outdoor activities, high-tech experiments and experimental lessons.

Our study demonstrated that it is important students to understand and learn the concepts being taught and their presence in their daily life, becoming thus able to connect science education with real life issues. This is in line with ideas of Bell and Lederman (2000) who assert that it is not enough merely to educate students on scientific concepts, students need to understand why scientific ideas should be used, and to value its relevance to their everyday lives and decisions.

Teacher's relationship with students plays a key role in engaging them in science education. A good communication between teacher and his/her students can attract and motivate students, can facilitate understanding and support better school achievements, as shown in US National Science Education Standards (1996): *"Actions of teachers are deeply influenced by their understanding of and relationships with students. The standards for science teaching require building strong, sustained relationships with students."*

The pedagogical approach that we proposed, of motivating students to learn science by developing and implementing engaging and fun activities, has the potential to promote engagement in science through a conceptualization of science-as-practice over science-as-learning, which takes place in a variety of formal and informal learning contexts and incorporates fun and motivating activities. This is convergent with findings of other studies (Collins et al., 1989; Nersessian, 2005; Ball and Cohen, 1996; Clandinin and Connelly, 1991; US National Research Council, 2007) pointing at the existing crucial shift from typical science instruction to science-as-practice and exploring how to teach the skills in the context of their application.

It is important to point out here that overall we identify very good match between the activities and tips we provided in the Literature Review on how to develop engaging science education activities and the statements and opinions of teachers participating to the Focus Group.

Summing up the ideas expressed during the Focus Group and throughout the Literature Review, we can conclude that:

- Outdoor activities and experimental lessons are preferred by students instead of the theoretical and traditional ones;
- Games and competitions are means by which the lessons could be made more attractive and motivational;
- Good communication and an informal way of leading a class facilitate learning by rising the students' interest, attention and motivation;
- Science learning should definitely be connected to the day by day reality and life; in this way, it becomes appealing to the students because they find the practical applicability of the information

they gather;

- Innovative didactics should be the base of science teaching;
- Teachers should adapt their classes to the students' needs, expectations and life; thus, the modern socializing tools should not be avoided; on the contrary, they have to be used when necessary;
- A key point is the utility of the digital tools, ICT and Web 2.0 technologies; they are really preferred both by educators and learners;
- ICT and Web 2.0 technologies could replace the lack of laboratory facilities, providing high-tech experiments; through the online platforms, students could easily apply what they learn and find more and more information;
- Course books should definitely be avoided and replaced by digital lessons which provide an interactive way of learning.

As it has resulted from our research, in this paper we have attempted to emphasize on the use of digital tools, mobile devices and Web2.0 technologies in developing engaging activities to address the challenge of engagement in science. Teachers, educators, trainers and other relevant stakeholders need to master these modern devices and tools and thus be better prepared to engage their students in science education This can be achieved through innovative an innovative approach to science teaching and learning and by making learning science fun and relevant to students' contexts.

Acknowledgements

The results presented in this work have been obtained in the framework of the project *"SciFUN: Making Learning Science Fun"* (2015-1-RO01-KA201-015016, www.scifun.eu) financed by the Erasmus+ Programme of the European Union, between 31st of December 2015 and 30th of December 2017. The project coordinator was University of Piteşti (Romania) and the partners were Group for European Integration (Romania), Centre for Advancement of Research and Development in Educational Technology (Cyprus), University of Peloponnese (Greece), INNOVADE LI (Cyprus), University of Lodz (Poland), Louth and Meath Education and Training Board (Ireland).

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