AN INNOVATIVE VIRTUAL REALITY EDUCATIONAL ENVIRONMENT FOR SCHOOL PHYSICS EDUCATION: SLOVAKIA CASE

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Abstract

Over the past decade, the OECD Programme for International Student Assessment, PISA, has become the world’s premier yardstick for evaluating the quality, equity and efficiency of school systems. The latest PISA assessment in 2015 focused on science and according to results of this survey in many European countries the students achievements in science are alarmingly low and special actions are needed to address and assists school to improve science education.

For example, in Slovakia average score in science as percentage difference from the OECD average is -6,5%, in Greece -7,7%, Romania -11,8% and even in Cyprus -12,8%. So, there is a clear necessity to address students' science and physics performance and improve the quality of education, assist students' learning and also enhance their understanding and their performance. These are absolutely necessary in order to achieve the aim of the EU to reduce by 2020 the proportion of 15 year-olds students with low achievement in science to less than 15%. So, specific actions and initiations should be designed towards this direction.

The article presents the project “WoP - An innovative virtual reality educational environment for school physics education” which aims to assist students in studying physics domain with the utilization of innovative technologies like 3D virtual reality.

The main aim of WoP project is to develop an educational environment developed innovative educational infrastructure offer immersive and efficient learning opportunities, engaging students in various educational activities, learning scenarios and offering students an attractive, entertaining and efficient way to learn various topics of the challenging domain of physics. The virtual educational environment and the laboratories are designed in a way that support students to form appropriate mental models of involved concepts, by visualizing them and allowing interactions with the virtual phenomena and processes.

The article also presents findings of an analysis the actual state in the physics education in secondary education schools in the partners’ countries, particularly in Slovakia.

Keywords: Physics, STEM education, Virtual reality, 3D.

1 INTRODUCTION

School education is the most important educational period when students create learning mechanisms, construct knowledge and develop basic skills and acquisition methods. The quality and the effectiveness of school education is of strategic importance in all countries and a top priority in the EU agenda. Science education has a strategic importance for the further development and innovation, the economy and the society. A science courses are of particular importance in primary and secondary school education and is considered necessary more than ever before students to have a solid background on science and physics courses [1]. However, students find science and physics courses to be the most difficult and challenging and face particular difficulties in properly understanding and comprehending the various topics they consist of.

According to TIMSS surveys conducted in European level [2] the students achievements in science is alarmingly low in many EU-27 countries and special actions are needed to address and assists school science education. In WoP project's partners countries an analysis shows that: students till 8th grade in Cyprus have particular difficulties in science and their performance is substantially poor. The same situation is in Romania, which has considerably the lowest average achievement across EU in science courses, indicating an average performance of 428 points. This is the poorest on European level where the average performance is indicated to be approximately 501,3 points. In Greece, students demonstrate a low school science performance of 470 which is substantial lower than the mean EU.
The same stands for Italy and Slovakia as well, where students' performance in science was 489 and 490 respectively.

In addition, the proportion of students lacking basic skills in science is especially high in Romania where about 40% of students under-achieve in science. In Greece the percentage of underachieving students in science is also alarmingly high and is approximately 25%. Also, in Italy and in Slovakia the percentage is 21% and 19.5% respectively. So, there is a clear necessity to address students' science and physics performance and improve the quality of education, assist students' learning and also enhance their understanding and their performance. This is absolutely necessary in order to achieve the aim of the EU to reduce by 2020 the proportion of 15 year-olds students with low achievement in science to less than 15%.

In this spirit, the WoP project aims to assist students in studying physics domain with the utilization of innovative technologies like virtual reality. Specifically, developed 3D virtual reality educational environment possesses innovative educational infrastructure, and offers immersive and efficient learning opportunities, engaging students in various educational activities and learning scenarios. The 3D Virtual World offers to students an attractive, entertaining and efficient way to learn various topics of the challenging domain of physics. The students have the ability to virtually visit laboratories, perform experiments, explore procedures and examine the ways that are conducted.

The virtual educational environment and the laboratories are designed in a way that supports students to form appropriate mental models of involved concepts, by visualizing them and allowing interactions with the virtual phenomena and processes.

With the aim to cover most important topics under the field of physics and effective learning approach, an overview and an analysis of actual state in physics education in partners' countries have been provided at the very beginning of the project realisation. The prepared report is very important not only in order to identify most important topics in physics fields, but identify the suitable techniques and learning approaches that are used in the 3D World courses, focusing on the requirements for efficiently training students through virtual simulations and learning activities.

2 METHODOLOGY

In the primary and secondary education (ISCED 2 and ISCED 3), the most part of European countries adopt an approach in which science is a separate subject, and the sciences are often a specialized curriculum.

Between 2005 and 2011 more than half of European countries either reformed their primary and secondary education curricula or started planning reforms [3]. Most of these reforms were triggered by the need to bring curricula (including science subjects) more closely in line with the EU key competences approach [4].

As consequence, the sciences are not teach with the same level of difficulty and/or not all students studying science subjects for all the years of ISCED level 3.

In all European countries, science education in ISCED1 level is teaching as a general subject that integrated chemistry, physics and biology. In many EU countries the same approach continues for the years of higher primary and lower secondary education (e.g. Italy), in other, like Slovakia, science teaching is divided into the following separate subjects: biology, chemistry and physics.

The starting point of the Reports on Physics Education in Schools around Europe was the TIMSS survey (Trends in International Mathematics and Science Study), that is a regular international comparative assessments of student achievement in mathematics and science.
In particular, we focus on the science education section of the TIMSS administered for the students of the 8th grade.

Starting from the TIMSS 2011 survey, the most significant items were selected in order to create a specific survey to be administered to a sample of schools in Cyprus, Greece, Italy, Slovakia and Romania. The realized survey contributes to define the European picture of the science education, although it is not significant from a statistical point of view.

As a methodology for analysis we used qualitative data analysis at the students' and teachers' levels. As analysis methods have been used questionnaire survey but interviews, focus groups and data analysis from existing sources like an Eurostat, information published by European Commission, national bodies like ministries or umbrella organizations as well databases and results from PISA and TIMSS survey.

In order to analyse the student responses of some European countries we have selected the following items:

1. How often students use the computer? (At home, At school, Some other place)
2. Is the teacher clear during the explanation?
3. How students employ to perform the science tasks?
4. How often teachers assign homework?
5. Are the sciences a more complex matter than other classmate?
6. How much do you agree with this statement about learning science? (I enjoy learning science, I wish I did not have to study science, I read about science in my spare time, Science is boring, I learn many interesting things in science, I like science, It is important to do well in science)

For teachers we have selected the following items:

1. Do you use computers in the classroom?
2. How often do you usually ask them to do the following? (Observe natural phenomena, Watch me demonstrate an experiment or investigation, Read their textbook or other resources materials, Conduct experiments or investigations, Design or plan experiments or investigations, Have students memorize facts and principles, Use scientific formulas and laws to solve routine problems, Give explanation about something they are studying, Relate what they are learning in science to their daily lives, Do filed work outside of class, Take a written text or quiz)
3. Do you think that is comfortable to use a computer during school lessons?
4. A computer available during the science lessons?
5. How often do you have the students do the following computer activities during science lesson? (Practice skills and procedures, Look up ideas and information, Do scientific procedures or experiments, Study natural phenomena trough simulation, Process and analyse data)

The complete report is available on the WoP project web site [5]. In the Result section we present some specific findings for the Slovak Republic.

3 RESULTS

3.1 Physics Education in Secondary Education Schools in Slovakia

In general we can say that the data for Slovakia contribute to define the European picture of the science education as it was presented in the PISA and TIMSS surveys.

3.1.1 Analysis at the student level

The Figure 2 shows the frequencies of the use of computers in different context: at home, at school and in some other place. We can note that Slovakia has a similar trend as the rest of EU countries from TIMSS survey - a very high percentage always greater to 70% of students that use the pc at home daily.
In the Figure 3, we can note that for the students the science is likely and fun. However, a significant part of students think that the sciences are boring and a matter that they would not have wanted to study.

The Figure 4 shows the perception of the students about the teachers’ explanation skill ("agree" indicate that the teacher is clear in his explanation, "disagree" that the teacher is not easy to understand during the explanation). Positive is, even if the dependence of the teachers’ clarity or the difficulty of the topics has not been considered, that the response indicating that students agree a lot/agree a little that teachers are clear. On the other side, the highest numbers of response “disagrees a little” opens the space for the discussion about the way of realisation the science education.

Figure 4: How much do you agree with the statement "My teacher is easy to understand" about your science lessons?
The Figure 5 and Figure 6 are referred to sciences homework. The most frequent answer about the homework in science was “less than once a week” and the most common mode is 16-30 minutes, in fact most of students take a time ranging between 16 and 30 minutes to carry out the tasks of science and very few students take longer than 90 minutes to do a task of science.

3.1.2 Analysis at the teacher level

The emphasis in the case of teacher survey was focused on a methodology and didactical tools used for science education.

The Figure 7, that concerns the use of computers during lessons, shows some very interesting aspects. It is clear that all teachers use computers for preparation of lessons, but a special mention goes to the fact that almost 20% of them do not use computers in their classrooms. Responds on the following questions can clarify the reasons of this fact (Figure 8).

![Figure 5: How often does your teacher give you homework in science?](image1)

![Figure 6: When your teacher gives you science homework, about how many minutes do you usually spend on your homework?](image2)

![Figure 7: Do you use computers in your teaching in any of the following ways?](image3)

![Figure 8: In teaching science to the students in this class, how often do you usually ask them to do the following?](image4)
The Figure 8 shows that the most frequent activities in Slovakia during the hours of science is the memorize facts and principles with teacher’s explanations about something students are studying. For the present time these forms of learning activities are not in line with the modern way of education, where the emphasis lays on the creative learning and critical thinking.

Figure 9: When you teach science to this class, how do you use the following resources?

In Figure 9 we can see how many times different tools are used during the hours of science; the textbook is the basic instrument and the computer is considered to be only a support tool. The high number of responses "not used" confirms that many Slovak physics teachers do not use the computer to carry out their education activities.

3.2 Experiences of teaching methods applied to Physics

When we talk about teaching methodologies there is no way to identify one that is good for all student and all contexts. Teachers have access to a variety of strategies, methods and teaching techniques which are to be intended as "tools of the trade" to choose from depending of not only their teaching style preferences, but also the economic and social student context, the topic that will be addressed and the typology of goal to be addressed.

In the following paragraphs, we will present methods and technologies used in WoP project and show some experiences of their use in the sector of physics education.

3.2.1 Virtual reality and education

The virtual reality is being more and more used in the education, allowing the student to find out, to explore and to build his own knowledge. The constant evolution of the technology is taking the education to new ways, much more attractive to the students, making possible the use of new tools, taking to an evolution on the teaching process. The Virtual Reality takes an important place in this evolution [5] and virtual worlds are playing an increasingly important role in education. It was estimated that over 200 universities or academic institutions are using Virtual Reality as a support for their students. 3D virtual worlds are often used for constructivist learning because of the opportunities for learners to explore, collaborate and be immersed within an environment of their choice [6].

Formal learning, usually delivered by trained teachers who are following a specific list of subjects, is part of one of three forms of learning, the others being non-formal and informal learning. Formal learning should not be confused with ‘formal learning theory’, which, as the Stanford Encyclopedia of Philosophy reminds us, is: “the mathematical embodiment of a normative epistemology”[7].

Informal learning can be defined as a particular way of learning which arises from the activities and interests of individuals and groups. After having identified and selected interests expressed by learners, informal-learning activities (discussion, talks or presentations, information, advice and guidance) are carried out in a flexible and informal way, in informal community locations.

The educational software for Virtual Worlds helped to take the formal, informal and non-formal learning from classrooms to the computer labs, making the teaching and learning process more interesting and pleasant to the students, facilitating the teacher’s work during the evaluation performance too.

Virtual learning opens the doors for people to access the best kind of education by blending together the best of the real world, the best of the internet and online applications, and the best of the virtual world technology so that the most modern techniques are utilized to obtain that education.
3.2.2 Virtual 3D World for Teaching Physics

Based on the findings in the report “Physics Education in Secondary Education Schools around Europe”, the WoP 3D World has three different regions, each one dedicated to one principal topic of Physics:

- mechanics,
- properties of matter,
- electricity and magnetism.

Each region contains a variety of different learning resources, both static (text, images, videos) and interactive (3D objects, puzzles and quizzes, talking characters, etc.).

The learning experience follows the necessary pedagogical methods focusing on gamification and learning-by-doing ideas. More specifically the students are guided by Non Playable Characters (NPC) to follow certain quests inside the 3D World. Each quest has a clear learning goal and requires that the student:

1. reads the relevant theory,
2. applies the concepts in experiments/laboratories,
3. completes assessment tests to receive a reward.

The tests are a simple quiz of multiple choice questions or a simulated scenario where the student needs to apply the theory to solve a situation. Each region also has areas that support the teacher (logged in as an avatar) to give lectures to the students or test their progress. Finally special areas where students are able to design their own material, the teachers can organize special assignments that can test the students in a highly creative and imaginative spirit are available (Figure 11).

The learning materials include many different formats depending on the learning topic being taught such as text, images, multimedia and 3D Objects (Figure 10).

4 CONCLUSIONS

Over the past decade, the OECD Programme for International Student Assessment, PISA, has become the world’s premier yardstick for evaluating the quality, equity and efficiency of school systems. The latest PISA assessment in 2015 focused on science and according to results of this survey in many European countries the students achievements in science are alarmingly low and special actions are needed to address and assists school to improve science education.

The project “WoP - An innovative virtual reality educational environment for school physics education” aims to assist students in studying physics domain with the utilization of innovative technologies like 3D virtual reality. An educational environment developed in the frame of WoP project introduce the innovative educational infrastructure offering immersive and efficient learning opportunities, engaging students in various educational activities, learning scenarios and offering students an attractive, entertaining and efficient way to learn various topics of the challenging domain of physics. The virtual educational environment and the laboratories are designed in a way that support students to form appropriate mental models of involved concepts, by visualizing them and allowing interactions with the virtual phenomena and processes.

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