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Procedia Social and Behavioral Sciences 15 (2011) 1177–1182

Procedia Social and Behavioral Sciences

WCES-2011

Remarks on pupils' feedback concerning the implementation of virtual experiments in Science teaching

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Abstract

The huge steps of ICT development in the last decades proved that ICT tools provide many advantages in Science teaching by using not only traditional methods but also modern pedagogical approaches. One of the new technologies that can be used by the teachers in teaching Science is offered by virtual instrumentation (VI). Using this technology, different virtual experiments or simulations of real processes can be designed. These virtual experiments can be used in the educational contexts for simulating the real phenomena which are taking place in different systems. In addition, the virtual experiments or simulations can be used by the teachers and students in the classroom in order to assure a logical learning process, based on practical aspects.
The paper presents some conclusion results from the feedback expressed by over 2800 pupils from five countries, concerning the use of new virtual experiments designed by 146 teachers who participated to the training modules *"Virtual Instrumentation in Science Education"* organized in the frame of Socrates-Comenius 2.1. European project *"VccSSe - Virtual Community Collaborating Space for Science Education"*. Different aspects and interpretation related to the challenges and difficulties encountered during the implementation process are also included. The results have proved that the use of virtual instruments can produce benefic changes concerning the social dynamics of the classrooms. The information - presented in a new way - has a great influence on development of an authentic learning.

Keywords: virtual instrumentation, virtual experiment, pupils' feedback, Science teaching, Comenius 2.1 Project;

1. Introduction

During the last decades a big number of researches have been focused on study the advantages and efficiency added by using of virtual instrumentation (VI) in the logical and critical learning of different Science phenomena. A big part of these studies emphasized that VI represents a real revolution in the field of instrumentation and its power in creating simulation-based learning environments became well-known.

Based on these studies, a lot of programs have been developed to train the teachers on how to implement different ready-made virtual experiments, in order to benefit by their advantages, when complex phenomena are taught, and real experiments are difficult to be organized for proving different scientific aspects. In time, teachers became familiar with the use of the virtual experiments and felt comfortable to design their own virtual experiments

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1877–0428 © 2011 Published by Elsevier Ltd.
doi:10.1016/j.sbspro.2011.03.259

with the view to adapt them, on the one hand to certain learning contents and, on the other hand to the pupils' level of understanding. Analyzing the efficiency of virtual instrumentation during the teaching process of different Science areas, the recent researches have emphasized that the use of the simulations is benefic for understanding the Science concepts. The results of the studies showed a bigger progress of the pupils due to a better understanding of the real world through virtual instrumentation. In addition, a higher pupils' motivation in learning different Science concepts have been reported when simulations are used by the teachers.

Due to those optimistic results, the use of virtual experiments in Science teaching has grown continuously in the last decades. Different software applications have been developed for designing virtual experiments that simulate different complex phenomena which are taking place in different systems.

More and more virtual libraries that contain a lot of virtual experiments can be freely consulted on the Internet by the teachers and pupils for explaining different complex phenomena. These experiments became a suitable solution for teaching the pupils how to design their own learning experiments, for a better and deeper understanding of the theoretical concepts.

The following paragraphs illustrate some aspects concerning the impact of virtual experiments implementation in the teaching/learning process, on different topics of the Science areas, by presenting the results of the pupils' feedback analysis. The study was developed in the frame of the three years Socrates-Comenius 2.1 project *"VccSSe - Virtual Community Collaborating Space for Science Education"* (code 128989-CP-1-2006-1-RO-COMENIUS-C21, co-funded by the European Commission). Nine partner institutions from five different countries (Romania, Spain, Poland, Finland and Greece) were involved in this project by designing teaching materials, developing training modules and virtual experiments, assisting the teachers during the implementing process and making studies related on how to use the virtual instrumentation for enriching the pupils' motivation to learn Science and understanding the scientific aspects of real phenomena that surround them (Gorghiu G., 2009).

2. Description of the procedure

During the VccSSe project-life, the partnership designed the training materials and organized the Training Modules *"Virtual Instrumentation in Science Education"*. 363 teachers from five European countries (Romania, Spain, Poland, Finland and Greece) were enrolled in the training process. 206 of them finalized the training modules and designed - using the specific software selected by the partnership - 218 new virtual experiments ready to be used in different Science lessons (Gorghiu et al., 2010). At the same time, teachers also prepared specific learning objects that included the new designed experiments. During the implementation stage, 146 teachers implemented the new products in their classrooms. It was a challenge and a wonderful possibility to motivate not only the participating in-service teachers but also over 2800 pupils, giving them a new dimension to learning.

During the training process and the implementing period, the partner institutions focused on the analysis of different aspects, like problems encountered by the teachers, the advantages and disadvantages of the use of virtual experiments during Mathematics and Science lessons, and the impact of those instruments at the pupils' level. In this way, a collection of assessment tools have been produced by the Evaluation Group of the project partnership, in order to evaluate the teachers and pupils opinions related to the use of this new technology in Mathematics and Science teaching and learning process. Two different questionnaires were designed for initial and final evaluation of the teachers who participated to the Training Modules and other two different questionnaires concerning the impact of the virtual experiments in the classroom, addressed to teachers and pupils, were part of the assessment tools. The Pupils' Feedback Questionnaire containing five questions was applied to pupils who participated to the lessons that involved the implementation of a new virtual experiment, designed by the Science teacher, who achieved the Training Modules. The Questionnaire was structured on the following questions:

1. What did you like most about the lesson where virtual experiments were used?
2. What didn't you like about the lesson where virtual experiments were used?
3. Did the use of the virtual experiments help you understand the Sciences concepts?
4. Would you like the teacher to use virtual experiments within the Sciences lessons again?
5. Did you enjoy the lesson where the new technologies were used more than the regular ones?

In the final part of the questionnaire, the pupils were asked to add any other comments concerning their experience on using virtual experiments within the Sciences lessons.

At the end of the implementation process, the form was filled in by 2860 pupils from Romania, Spain, Poland, Finland and Greece, enrolled in all education levels, from primary to upper secondary school, after using of different virtual experiments in teaching Mathematics, Physics, Chemistry, Nature Sciences and Technology.

3. Results and Discussions

The impact of using virtual instrumentation for teaching/learning different Science concepts and understanding complex phenomena was studied by analyzing the pupils' answers collected from the *"Pupils' Feedback Questionnaire"* designed by the Evaluation Group and delivered to every pupil after the implementation process. The analysis was performed on a sample of 2860 pupils (8-18 years old) from five countries, as figure 1 emphasizes. In addition, the distribution of pupils (on various educational levels) who participated to the implementation process is presented in figure 2.

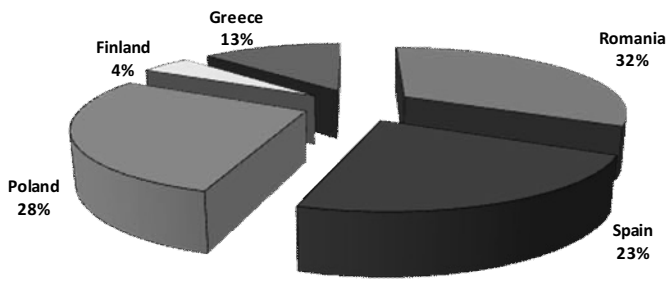

Figure 1. Distribution of pupils by country

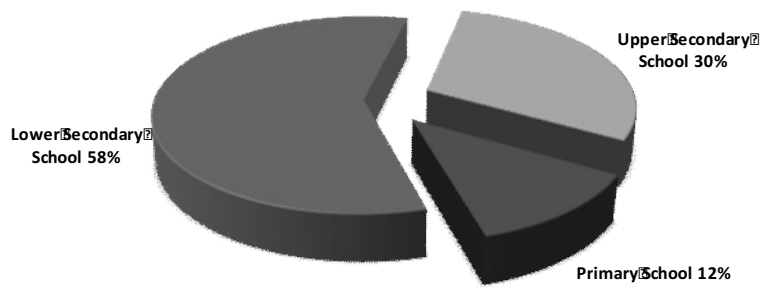

Figure 2. Distribution of pupils by level of education

A total number of 926 pupils (8-18 years old) from Romania were involved in the educational process at all educational levels (16% of them were from primary school, 55% from lower secondary school and 29% from upper secondary school). After the implementation of their virtual experiments in the classroom, the teachers considered the implementation process to be highly successful in terms of enhancing pupils' learning. The deeper understanding of the theoretical concepts, the easier confirmation of a model or a hypothesis by using the new virtual experiments and last but not least, the increasing of pupils' motivation in learning Science, have been identified during the teaching process of different Science areas, with the help of new virtual experiments. This aspect is in concordance with other recent papers concerning the critical impact of the teachers' beliefs about the benefits of using ICT in the classroom (Dumitrescu et al., 2009).

In some lessons, the virtual instruments interfered only in certain steps of the lesson, while in others, the whole lesson have been led by using this kind of instruments. Analyzing the pupils' opinions, it can be concluded that all

the lessons have been animated by using the virtual instruments during the teaching process, if we are taking into consideration that 41.5% of pupils considered the use and implementation of the VI in the teaching / learning process very useful and found it as a suitable way for a better and easier understanding of different subjects, 34.2% of them emphasized the achieving of new knowledge and abilities, other 21.3% saw the virtual instruments like positive aspects related to the using of computer in the classroom and only 3% of pupils didn't emphasize any positive aspect of the VI implementation during the teaching process. The pupils' answers highlighted the fact that the lessons were more interactive, and they could understand easier and quicker the physical lows or phenomena explained by the teacher. They appreciated the fact that a physical phenomenon could be split into operations and the processes could we observed in motion - a fact that facilitated its understanding. An aspect which cannot be neglected in pupils' answers was that they appreciated the possibility to cooperate in those lessons.

Regarding some negative aspects encountered during the use of the virtual experiments in different lessons, the pupils' answers illustrated different things that affected the implementation process, like the low number of the computers used, non-approaching of more complex subjects, the lack of time for understanding of all the aspects related to the teaching process or presenting the tasks results. Beside those problems, most of the pupils (99%) were delighted to use the virtual instrumentation during the teaching/learning process, a great part of them (77%) even regularly.

Concerning other pupils' comments to the use of virtual experiments in Sciences teaching, the pupils' reports contain an interesting mixture of pupil enjoyment, enthusiasm, motivation and professional presentation. But, the most important feature which pupils highlighted was the interactivity of the products, namely the fact that the virtual experiments could be manipulated by the pupils, through the parameters and variables of the experiments modification. This fact stresses the main role of the virtual instrumentation in teaching Sciences lessons; it replaces the real instrumentation which in Romanian schools is sometimes absent or obsolete, and, on the other hand, it permits developing experiments without exposing pupils to risks.

Other 644 Spanish pupils from primary and lower secondary school level were involved in the implementation process of the new virtual experiments in areas like Mathematics, Physics, Chemistry and Technology. The main comments related to what aspects liked most to pupils during the use of virtual experiments in Sciences lessons are presented in figure 3.

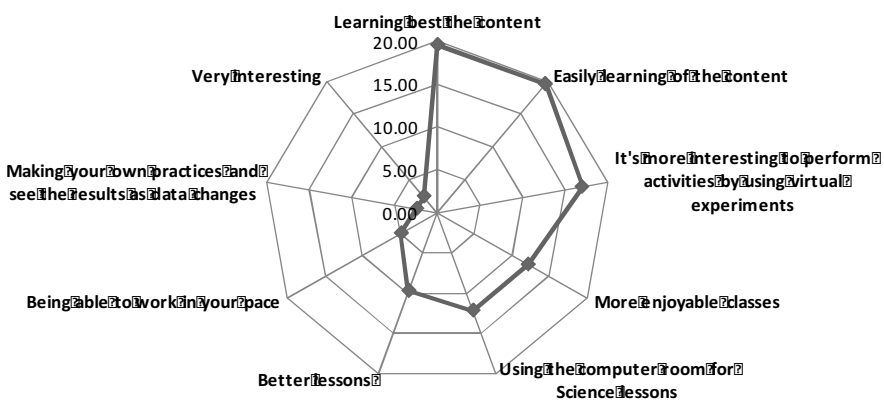

Figure 3. Pupils' answers related to what they liked most about the using of virtual instrumentation during the lessons (in percentages)

The pupils' answers about what they didn't like about the lessons where virtual experiments were used emphasized that 30% of pupils didn't make any comment to this question and 70% of them agreed that "no, everything was very interesting" during the lessons. The obtained results concerning the help of the virtual experiments for a better understanding of the Sciences concepts proved that all the pupils agreed that virtual instrumentation helped them to understand better the subject taught during the lessons. In addition, all the pupils declared that they would like the teacher to use regularly the virtual experiments within the Sciences lessons.

A total number of 799 pupils from Poland, 14% of them enrolled in primary school, 46% in lower secondary school and 40% in upper secondary school were involved in the implementing of the virtual instrumentation in different Mathematics and Science lessons. The data collected concerning the help offered by the virtual experiments for a better understanding of the Sciences concepts emphasized (figure 4) that most of the pupils agreed that virtual instrumentation assured the better understanding of the topics presented during the lessons. At the same time, all the Polish pupils declared that they would like the teacher to use again the virtual experiments within the Sciences lessons; they oscillated between the regular and occasional use of this technology (figure 5).

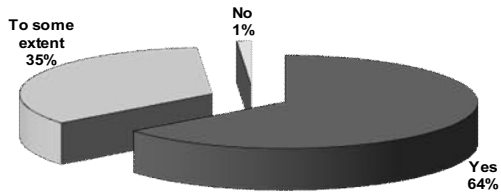

Figure 4. Pupils' answers related to the advantage of using virtual instrumentation for a better understanding of Sciences concepts

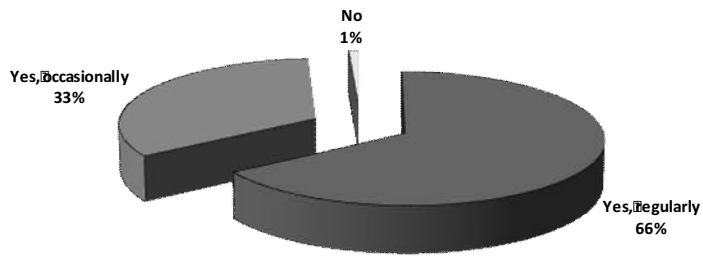

Figure 5. Pupils' answers related to their opinions about future use of virtual instrumentation in Sciences lessons

A number of 127 Finnish pupils completed the Pupils' Feedback Questionnaire as they were involved in the implementation of the Mathematics, Chemistry and Physics lessons, all of them being based on Java Simulations. The results obtained after the delivering of the questionnaires seem to indicate that pupils have liked the ability to explore the issue and to find out influences by changing of different variables. Two thirds of the pupils claimed that the simulations helped them in understanding the Sciences concepts. Even there were only two pupils not wanting to have simulations used again, most of the pupils would like to have them only sometimes, not often. The pupils commented the experiment as nice and they liked it as a way to help learning. To the open questions, the pupils expressed that they liked most that they could decide themselves how and what to construct, and least, that there was so little time to make the experiments.

During the implementation process within the Sciences lessons, a total of 340 Greek pupils have been involved. All the Greek teachers used the experiments performed within the context of the educational software Cabri-Geometry II. Concerning the pupils' answers to the 1st Question of the questionnaire - "What pupils liked about Virtual tools and experiments?" - a considerable number of pupils expressed their preference for the use of computers in their classrooms as suitable to their culture and era, in contrary to the use of paper and pencil. In their own words "The lesson became easier than in the paper and blackboard environment; when using computers, high grade of pupils understood the lesson". Some pupils also expressed their preference for group working.

Regarding the use of Cabri-Geometry II software, pupils expressed their interest in diverse ways including: a) drawing, b) experimenting, c) understanding, d) feelings, and e) scaffolding. Pupils expressed that everything was helpful when they used virtual tools and experiments. Specifically, they realized that the use of visual images was very helpful for them to easy understand the concepts in question. In addition, they expressed that the tools provided by Cabri helped them to use the mathematical rules, to automatically perform some specific geometrical constructions and measurements as well as automatic tabulation of numerical data. Finally, some pupils emphasized the diversity of tools provided as helpful to construct and elaborate with a plethora of geometrical shapes.

4. Concluding Remarks

The results presented above emphasize that the use of virtual instruments can change the social dynamics of the classrooms. The information and learning tasks are influencing the notion of authentic learning by changing the learning context. Analyzing the pupils' answers, the following aspects could be pointed out: a) the easier and deeper understanding of the content due to the using of VI tools; b) the pupils' desire to extend the use of VI tools in teaching process to other disciplines; c) the increasing of the quality of the learning process; d) the rising of the attractivity for the teaching modalities which combine VI with traditional experiments.

The feedback of pupils involved in lessons organized around virtual experiments created with the selected software, like LabVIEW, Crocodile Clips, Cabri Geometry and GeoGebra, allowed us to formulate some additional conclusions: a) Lessons that imply the use of VI tools are generally well received by the students, most of them appreciating that these lessons are motivating and challenging; b) VI facilitates the concept understanding process in Mathematics and Science lessons; c) VI applications allow for an interactive study of the scientific phenomena in focus, thus placing the teaching actions in the newest educational approaches and currents; d) Use of VI enhances the experimental features of certain school subject matters, thus improving their attractivity at the level of students.

Acknowledgements

This work was funded through the Socrates-Comenius 2.1. European project 128989-CP-1-2006-1-RO-COMENIUS-C21: *"VccSSe - Virtual Community Collaborating Space for Science Education"*. The support offered by the European Commission, Education and Training, School Education: Socrates: Comenius and the Education, Audiovisual and Culture Executive Agency as responsible for the management of EU's programmes in the fields of education, culture and audiovisual, through the project mentioned above, is gratefully acknowledged.

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