VIEWS OF TEACHERS REGARDING THE CLASSROOM EFFECTIVNESS OF VIRTUAL INSTRUMENTATION USED IN SCIENCE TEACHING AND LEARNING

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Abstract:
The present paper presents the opinions of European Science teachers that explored the usability of virtual instrumentation tools and experiments in improving Science teaching and classroom achievement. After designing and applying virtual instrumentation based learning objects into classroom settings, teachers reflected upon the importance of using virtual instrumentation in their teaching, the educational components that improved due to the new teaching tools, the difficulties they encountered as well as on the improvements that would make in the following teaching situations based on virtual instrumentation.

Keywords: virtual instrumentation tools; effective teaching and learning; views of Science teachers; computer based Science teaching.

1. Introduction

The present study is based data collected during one of the final phases of the three years European Comenius 2.1. project: Virtual Community Collaborating Space for Science Education, that aimed at exploring the educational usability of virtual instrumentation tools in Science teaching and learning. The project included a teacher training stage that involved over 300 Science teachers in exercising the use of a selected set of virtual instrumentation software applicable in Science subjects teaching - Cabri Geometry II, Crocodile Clips, LabView and GeoGebra – and in guided creation of virtual experiments and learning situations that they later implemented into the classroom settings.

A number of 145 teachers implemented the learning objects (Science lesson plans and respective virtual experiments) created during the course into the Science class settings and reflected upon the experience gained and impressions collected. Data and discussions related with these reflections are presented here together with a number of interesting correlation conclusions.

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2. Background

The effect of context on students' actions and also on the solution strategies they adopt for the given problems is acknowledged by widely recognised studies of social psychology and constructivist education.

Field literature defines the ICT based educational context as consisting of the educational software and hardware medium, the student, the teacher, the interactions between teacher and students and the activity that students are presented with. The learning approaches developed by students acting in a context including educational software appear to be influenced by this context. Research proves that interaction with this computer environment focuses the students on the main points of the learning concepts and helps them to clarify the relations among the concepts included in this environment. Moreover, the computer environment gives students the chance to shape relations between formal and informal science and to make generalisations through specific cases. Researchers have argued that the computer environment can play a "scaffolding" role and support the development of science activity. For instance, Borba and Confrey [1] speak of the formation of a two-way relationship between the student and the educational software designer via the mediation of software in the actions of the former and the enhancement of the possibilities of the software by the latter.

The experience gained during the development of the Comenius 2.1. project mentioned above proved that the selected software serve best for developing a number of specific learning settings:

- demonstrations in Geometry, Physics and Chemistry;

Demonstration based on intuitive stimuli support logic understanding of abstract concepts, functions, relations and processes

- investigation and discovery based learning situations;

Possibilities of variables manipulation included in all the software explored, doubled by heuristic questions and instructions create a favourable environment for deductions, generalization, conceptualization, formulation of laws and theories.

- problems;

Problems may be organized around concrete, contextualized data. Possibilities included in all software for creating and using mathematical calculation charts while manipulating variables of the problem supports understanding of relations between variables.

- repetitive exercises that lead to knowledge transfer;

By requiring students to modulate variables of a situation, repetitive exercising can be created, situations that support generalization and transfer of knowledge.

- explanatory situations;

Explanations are supported by intuitive stimuli, thus students understanding of abstract processes being enhanced. Visual stimuli offer anchors for retrieval of knowledge and relations.

- evaluative situations;

Specific knowledge consolidation situations may include evaluative questions that require deductions which prove understanding of mechanisms or relations between variables.

Each of the above learning situations may be fitted in different types of lessons selected according with one or more of the following criteria:

- type of learning teachers wish to support;
- type of contents to be delivered;
- curriculum requirements in terms of capabilities, values and attitudes;
- teaching style;
- students expertise;
- teacher computer expertise.

The analysis of the lessons and VI applications developed by the teachers show that they covered a limited typology of lessons to include the created virtual applications:

- lessons for delivery of new knowledge and skills based on previous life experience;
- lessons for delivery of new knowledge and skills based on previous knowledge
- consolidation of knowledge lessons (most of the applications);
- evaluation lessons.

3. Materials and method

A number of 145 teachers of Science subjects that teach in lower and upper secondary schools located in different European countries - Finland, Poland, Greece, Romania and Spain – participated in a guided process of designing and implementing a Science lesson situation that included one or more virtual experiments created with one of the following virtual instrumentation software: Cabri Geometry II and GeoGebra (for math contents), Crocodile Clips (for Physics and Chemistry contents), LabView (for Upper secondary school Physics contents). Consequently they filled in an „ impact questionnaire “meant to collect their impressions and opinions related to the usability of virtual instrumentation applications in Science teaching and learning.

The questionnaire consisted of 6 closed questions that referred to:

- importance the respondents give to the use of Virtual instrumentation applications ion Science teaching and learning;
- components that were positively influenced by the use of VIs in the classroom
- difficulties encountered;
- changes they would make in future implementation of VI applications;
- general perception of efficacy of the Science lesson based on VI tools;
- desire to use VI tools in future lessons.

The great majority of responding teachers have an important professional experience in educational settings. 34% of the participants have more than 16 years teaching experience while a cumulative percentage of 42% of the subjects declare more then 6 years teaching experience.

The respondents offered quantitative data that reflect their opinion on the efficacy of virtual instruments (VI) and tools they explored in the classroom for their teaching and for students learning. Data gathered will be reported and analysed in relation with the two main dimensions teaching and learning of Science contents.

The items of the questionnaire applied were regrouped in order to reflect the above mentioned dimensions. Table 1 presents the two groups of items:

Table 1. Items of the questionnaire focused on teaching (a) and learning (b)

<table>
<tr><th colspan="2">Items focused on</th></tr>
<tr><th>teaching (a)</th><th>learning (b)</th></tr>
<tr><td>VI represents a source of inspiration for you as a teacher</td><td>VI represents a good method for improving students’ learning skills</td></tr>
<tr><td>VI represents an effective learning environment</td><td>VI represents a means for improving students’ conceptual understanding</td></tr>
<tr><td>VI contributes to improving teaching strategy</td><td>VI contributes to improving students’ learning behaviour</td></tr>
<tr><td>VI contributes to improving classroom organisation</td><td>VI contributes to improving students learning results</td></tr>
<tr><td>VI issue difficulties regarding insuring classroom facilities</td><td rowspan="5">VI contributes to improving students’ motivation</td></tr>
<tr><td>VI issue difficulties regarding use of software</td></tr>
<tr><td>VI issue difficulties regarding use of hardware</td></tr>
<tr><td>VI issue difficulties regarding meeting the national curriculum requirements</td></tr>
<tr><td>VI issue difficulties regarding evaluation of students’ performance</td></tr>
</table>

Participants evaluated the applicability of each of the above mentioned items on a scale of 1 to 4 (where 1 represented an answer equivalent to “not at all” and 4 corresponding “to a great extent”).

4. Results

A general overview on the collected results show that the majority of teachers appreciate the VI based educational tools as effective for rather the learning process then the teaching activity. While learning is seen as improved or with important chances to be improved, teaching that involves special VI tools and application implies in view of the responding teachers - important challenges.

While most of the responding teachers considered that VI tools represent to a great extent a source of inspiration for them as teachers of Science subjects or as a contributing to improving subjects teaching strategy (see figure 1.a and figure1.b), 28% of them reported important or mild difficulties in meeting the national curriculum standards through VI applications based lessons (see figure 2). In our opinion, these answers reflect the limitations of the studied software in covering all standard contents of school Science curriculum.

Thus, for example, Crocodile Clips Chemistry does not cover the contents related to Laws of gases and have limits in applications of separations methods, while in CabriGeometry users may find difficult to draw conic figures through classic methods.

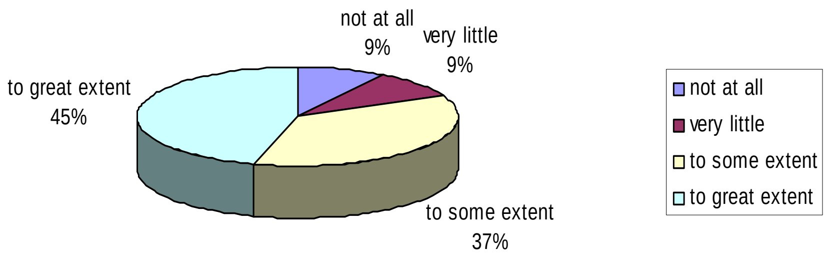


Fig. 1.a *Virtual instrumentation regarded as a source of inspiration for the teacher.*

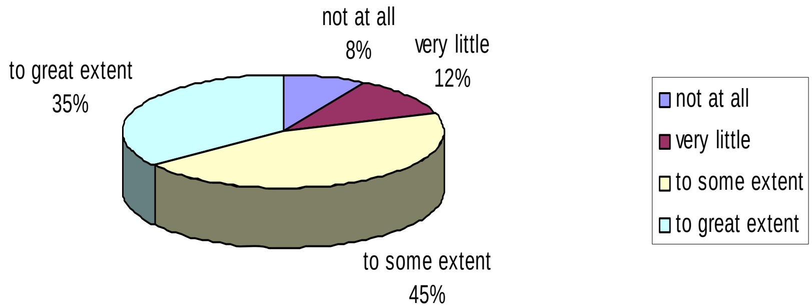


Fig. 1.b *Virtual instrumentation experiments improved the subjects' teaching strategy.*

However, comparing with the software admitted by some of the involved countries Educational Ministries that would offer teachers a limited number of readymade virtual experiments that may not be adapted to the level of class of age of students (the case of

AEL software in Romania), the studied software offer a large range of working tools to be used by teachers in designing suitable virtual applications.

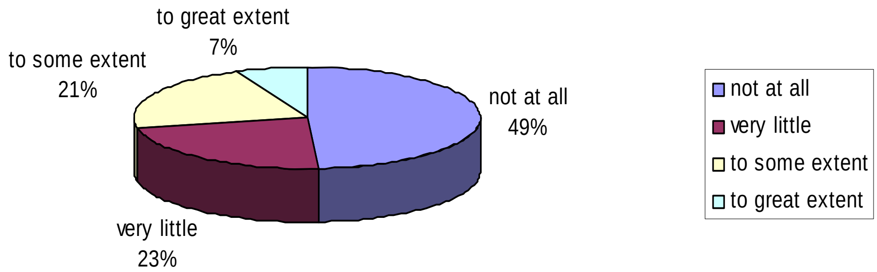


Fig. 2 *Use of VIs is made difficult by the urge to meet curriculum requirements.*

As VI experiments based lessons mainly support deduction of knowledge, teachers reflected that given the discovery based lessons, they may, to some extent encounter difficulties in evaluation students' performance (see figure 3). We expect that these difficulties are more likely in cases where evaluation tasks are not consistent with the knowledge and learning skills exercised during the lessons. The cases when deductions based learning is encouraged during lessons and readymade answers reproduction is required during evaluation are typical for such difficulties to be encountered.

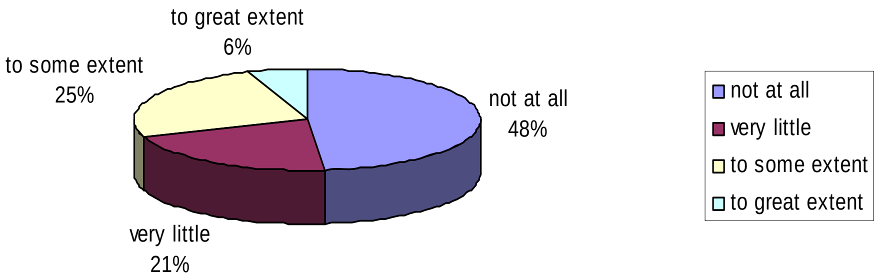
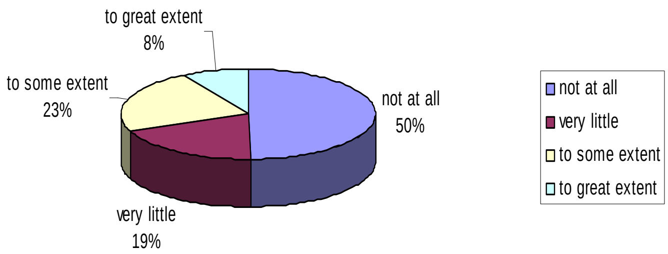


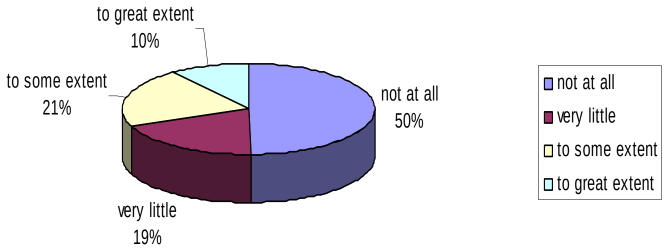
Fig. 3 *Use of VIs is made difficult by the specific of students' performance evaluation.*

The rest of the reported difficulties were related with use of software, where 31% of teachers identified these difficulties to some extent (figure 4.a).

The difficulties in use of hardware reported as important by 10% and mild by 21% of the subjects (see figure 4.b) were probably issued by the fact that in most of the participating countries students have limited access to the few computers existing in an ordinary classroom. Consequently, it is very probable that the teachers were the one who manipulated the virtual experiment environment and tools while students assisted. The situation was improved in the case the lesson took place in the computer lab and the applications could be observed individually or in small groups by the students.



a)



b)

Fig. 4 *Use of VIs is made difficult by the problems encountered in use of a) software; b) hardware.*

The answers given in question referring to difficulties encountered by teachers in insuring the classroom facilities confirm the above mentioned data (see figure 5).

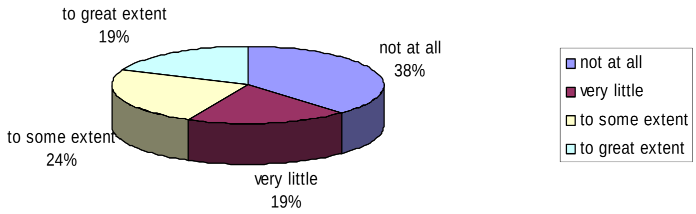


Fig. 5 *Use of VIs is made difficult by the problems in insuring classroom facilities.*

Despite the difficulties encountered, a large number of teachers considered that VI based lesson was an effective learning environment (47%) (see figure 6).

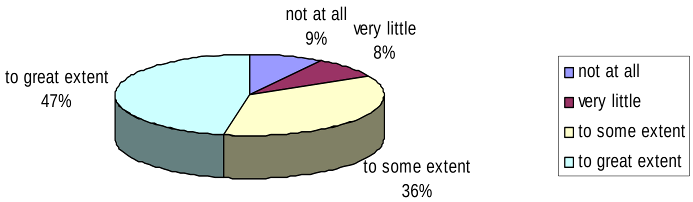
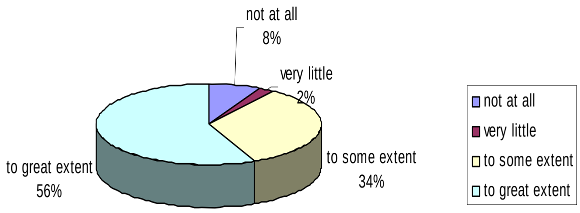


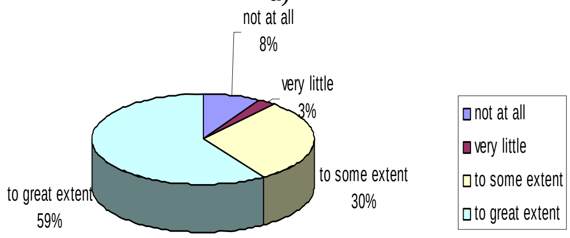
Fig. 6 *Virtual instrumentation is regarded as an effective learning environment.*

Moreover, being structured around an attractive computer based application the lessons facilitated the improvement of classroom organisation and management, to a great extent according to 29% and to some extent according to 51% of the responding teachers.

As far as students' learning is concerned, 51% of teachers consider that VI use represent a good method for improving students' learning skills (see figure 7.a) and for accelerating students' conceptual understanding (see figure 7.b) As most of the VI based applications require modulation of experimental space through altering the variables of an experiment and deducing the conclusions, the learning situation created supports deduction of knowledge and deep data processing.



a)



b)

Fig. 7 *Use of VIs contributes to: a) improving students' learning skills; b) improving students' conceptual understanding.*

Data obtained correlate with the answers that illustrate the motivational force of VI tools in determining students to actively involve in Science lessons. 64% of the responding teachers appreciated that VI tools contribute to a great extent to students' motivation while only 10% of them did not emphasised the motivational aspect of these special tools. (see figure 8).

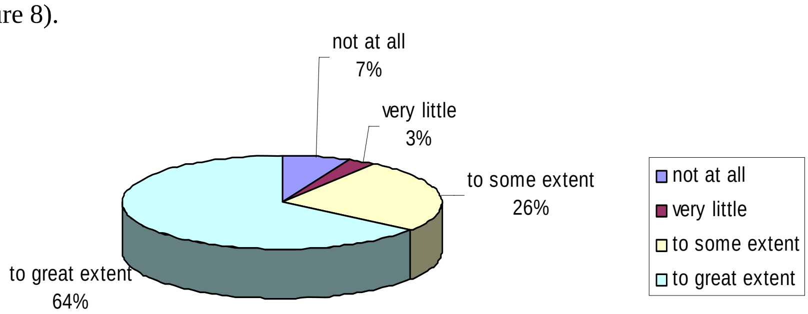


Fig. 8 *VI tools improve the quality of students' motivation.*

Indeed, the dynamic aspect of the experiments, the possibility of analysing the experimental environment while altering different variables included, as well as the very use of the computer and computer software proved to be motivational for students.

5. Discussions and conclusions

A great number of the responding teachers regarded virtual instrumentation applications as a source of inspiration for their teaching actions that should be used as an alternative to traditional tools, and as a means for improving students' understanding of abstract concepts. Generally, teachers did not find direct correlations between use of VIs and improvements in students' learning skills.

In fact, as far as different aspects of teaching and learning and impact of VIs, the best scores were obtained to the item regarding improving students' motivation for learning. Most of teachers in different countries reported that VI applications were the most useful for creating and maintaining students' interest for science topics as well as in obtaining better results in evaluations. This last aspect correlates with good scores given to improved understanding of concepts. Good scores were registered also in students' interactive learning mediated by VIs.

As for most of the teachers using virtual science applications in the classroom was one of the first experiences of this type, difficulties were reported in management of the classroom especially in: evaluation of students performance as well as in access to hardware or general management of students.

A number of teachers that work in more structured and less flexible curriculum systems (for example, the Romanian teachers) were concerned with meeting curriculum requirements through such special lessons. Indeed, displaying and working with virtual experiments in teaching and learning may be time consuming in certain school settings, for instance in case of a low number of computers for individual intervention, or in the case of teacher or students' low computer use abilities, or may not insure for hands on intervention for all students with consequences for their learning motivation.

Nevertheless, most of the teachers declared that lessons that include VIs were successful or rather successful and that they would decide to use again such educational applications, provided that they will have better and constant access to computers and would be able to involve students more in the creation and modulation of virtual learning spaces and experiments.

In conclusion, we appreciate that the project offered the occasion of experimenting with new and innovative pedagogical tools for optimizing the teaching and learning of Science subjects, topics that usually put problems to ordinary students. Apart from a motivational force and a more interactive learning atmosphere, the use of virtual tools and experiments in the classroom helps imagining abstract processes, brings concepts into applicative, concrete concepts, favour cooperation, manipulation of reality and formulation of conclusions through own cognitive efforts.

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Annex 1

Questionnaire about the Use of VI Impact in Classroom

Name and surname:

Subject taught:

Teaching experience (tick the appropriate box):

- ⦿ 0 - 5 years
- ○ 6 - 10 years
- ○ 11 - 15 years
- ○ 16 - more years

Please, select the number of the answer which corresponds most to your opinion on the scale where 1 is "not at all", 2 - "very little", 3 - "to some extent", 4 - "to great extent".

1. Evaluate how important virtual instrumentation is for you:

As a source of inspiration for you as a teacher	1	2	3	4
As an effective learning environment	1	2	3	4
As a teaching means to use from time to time	1	2	3	4
As a good method to improve students' learning skills	1	2	3	4
As a means for improving students' conceptual understanding	1	2	3	4

2. To what extent has the implementation of VI experiments in the classroom improved the quality of the following?

Students' learning behaviour	1	2	3	4
Your teaching strategy	1	2	3	4
Classroom organization	1	2	3	4
Students' cooperative work	1	2	3	4
Students' learning results	1	2	3	4

Students' learning products	◉ 1 ○ 2 ○ 3 ○ 4
Students' motivation	◉ 1 ○ 2 ○ 3 ○ 4

3. To what extent have the following aspects caused difficulties in implementing the VI experiments in the classroom?

Classroom facilities	◉ 1 ○ 2 ○ 3 ○ 4
Class activities management	◉ 1 ○ 2 ○ 3 ○ 4
Use of the software	◉ 1 ○ 2 ○ 3 ○ 4
Use of the hardware	◉ 1 ○ 2 ○ 3 ○ 4
Meeting the national curriculum requirements	◉ 1 ○ 2 ○ 3 ○ 4
Evaluation of students' performances	◉ 1 ○ 2 ○ 3 ○ 4

4. Do you plan to use VI tools in the future?

◉ Yes ○ No

5. If yes, what would you do differently next time when you decide to use VI tools in your lessons?

- ☐ I would introduce it in a different phase of the lesson
- ☐ I would involve students more in the use of the VI experiments
- ☐ I would pay more attention to the availability and workability of the hardware
- ☐ I would pay more attention to the availability and workability of the software
- ☐ I would improve the class activities management
- ☐ I would enhance the suitability of the experiment to the national curriculum requirements

6. Was the implementation of VI tools in the lesson a success?

◉ Yes ○ Rather yes ○ Rather no ○ No