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CASE STUDY ON THE INFLUENCE OF SIMULATIONS AND REAL EXPERIMENTS ON HIGHER ORDER SKILLS

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Abstract This research investigates the influence of computer simulations (virtual experiments) on one hand and real experiments on the other hand on the development of higher order skills, as well as the differences in those two approaches in the unit Electrical Charging.
The sample, which was investigated, consists of students in the second year of a gymnasium in Macedonia. There were two experimental groups and one control group. In one of the experimental group, the instruction was realized by means of computer simulations. In the other experimental group the instruction was realized by means of real experiments. The obtained results from both of groups were compared with the results from the control group, where traditional instruction was used. The same teacher performed the instructions in all of groups.
The pre-knowledge was tested with a pre test, as well as the acquired knowledge after the instructions. The same tests and analysis were performed with all three groups.
The results reveal that the approaches used in experimental groups give more quality knowledge and skills than the one in the control group.

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1. INTRODUCTION

The experiments have broad range of functions in reaching Physics. Theoretically, teachers express the fundamental role of the experiment during teaching and learning Physics.

Thus, instead of handbooks, that some times are compared with kitchen recipes, where usually students have to perform known procedures to express the physics Laws, it is requested to pass to the teaching and learning methods based on investigation, where the students are encouraged to recognize the problems, to build experiments by themselves and to analyze the results, which they did not know at the beginning, unlike in the case of traditional teaching. Shortly, the new methods try to put the students in a situation where they will think in the investigative, analytical and cooperative way, in a situation to decide and all that with practical and modern engaging.

Research and experimental work in natural sciences, particularly in Physics, keeps the students most of the time at the higher levels of thinking, i.e. students make analysis, synthesis, conclusions and so on. Thus, the students during the experimental work make analysis from the early beginning when they need to plan the investigation and make a certain sort of synthesis at the step of designing the investigation. So, when they obtain the results, they analyze again, which means they go back on the level of analysis, look for the relations, make conclusions, which takes them again to the level of synthesis and creation. This means that all the time, during the introduction, preparation and investigation, they go through this higher level thinking cycle. In this sense we offer them such activities.

In this direction, the computer represents a huge potential advantage. On one side the computer has already became a tool which cannot be substituted for scientific investigations, especially in Physics. But, on the other side, the application of the computers equipped with simulations also created possibilities for the improvement of the education process to a higher level, higher than that the traditional teaching allows.

On the other hand, the real experiments give quality that cannot be altered with anything else. The aim of this work is to discover which approach gives better understanding of physics concepts and stimulates higher level thinking. In order to investigate this, unit Electricity is taught to second grade high school students.

We decided to this research because most of the researches for understanding the physics concepts are done in mechanics [6], while in the other fields of physics this number is very small or no investigations have been done ([3], [8]). Therefore we think that there is need for research in other fields of physics, like electricity.

2. METHODS AND SAMPLES

2.1. The test

In this investigation the influence of the computer simulations and real experiments on higher level skills was examined. Test with 11 questions was used to measure the students' knowledge. First, pre test was used to measure the preknowledge. After the lectures, the students were post tested in order to measure the acquired knowledge. Delayed test was used 6 months later, to test the permanence of the acquired knowledge.

2.2. The sample

The sample consists of second year high school students from Macedonia. It was organized in two experimental groups and one control group. In the first experimental group real experiments were used and in the second experimental group computer simulations were used. The obtained results of these two groups were compared with those of the control group, in which traditional teaching method was used. The same teacher worked with all three groups. Also, with one of the experimental groups a delayed post testing was performed and compared to the post testing results taken directly after the lesson. The overall number of students that

were tested is 115. From these 29 students were in the group with real experiments, 31 students in the group with virtual/simulation experiments, and in the control group 29 students. 26 students from the experimental group, with real experiments, were post tested.

Prior to the delayed post test, the students were given the possibility to discuss the post test results with their peers, without telling them which of their answers are correct or not. The aim was to investigate the influence of the peer-to-peer discussion on the knowledge.

3. RESEARCH RESULTS AND DISCUSSION

In this work only three of the eleven questions given in the test will be discussed.

In order to discover how much students understand the electrostatic interaction of electrically charged objects, the following question was given to the students:

Two light neutral metal spheres hang on a thread. They are close enough to interact, but they don't touch each other (figure 1). Make a draw for the following situations:

- Both spheres are electrically charged with a plastic rod that is rubbed with woolen cloth,
- The distance between the spheres is increased compared to the situation a),
- Sphere A is electrically charged with plastic rod that is rubbed with woolen cloth, and the sphere B is charged with glass rod that is rubbed with silk.
- Both spheres are electrically charged with plastic rod, but the sphere A is charged more than the sphere B.

The distribution of student answers is given in Figure 1.

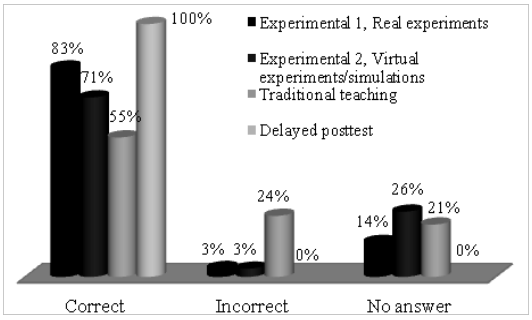


Fig. 1a.

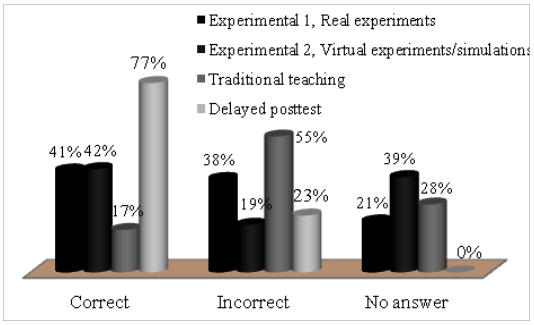


Fig. 1b.

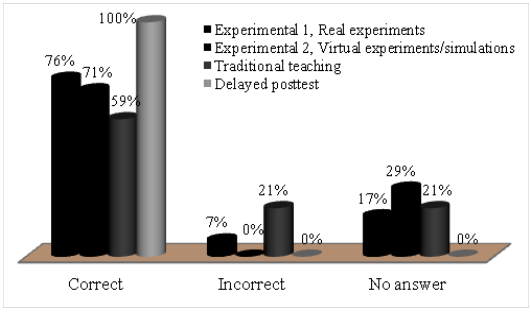


Fig. 1c.

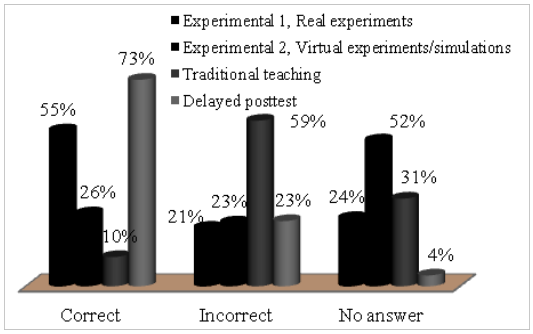


Fig. 1d.

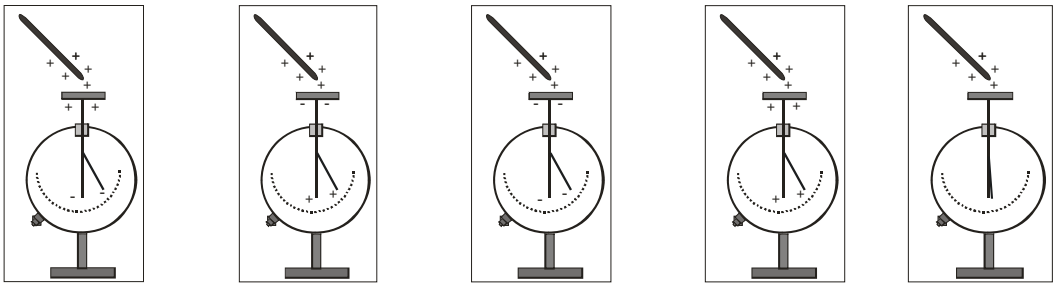
From the graphs in Figure 1 it can be seen that a higher percentage of students from experimental groups have answered correctly compared to the control one. Surprisingly, all students have correct answers at the delayed test. This means that teaching through previously prepared experiments compared to the traditional teaching gives better results.

The students from the experimental group working with real experiments achieved somehow better results than the one working with simulations. Each student had a chance to experiment and to see how the electrically charged objects set at a various distances interact with each other. We believe that this had huge influence on the knowledge they acquired.

Also, from figure 1 it can be seen that after the peer-to-peer discussion, the results are even better, because peer-to-peer discussion made the students more comfortable and free to ask about the things they did not understand. This is in agreement with result of other researchers [7].

The next question was to see how much do students understand the charging of objects by induction.

A positively charged rod is placed near the head of an electroscope. Which picture describes this situation best? Explain the answer.



A **B** **C** **D** **E**

The distribution of students answers are given in Figure 2.

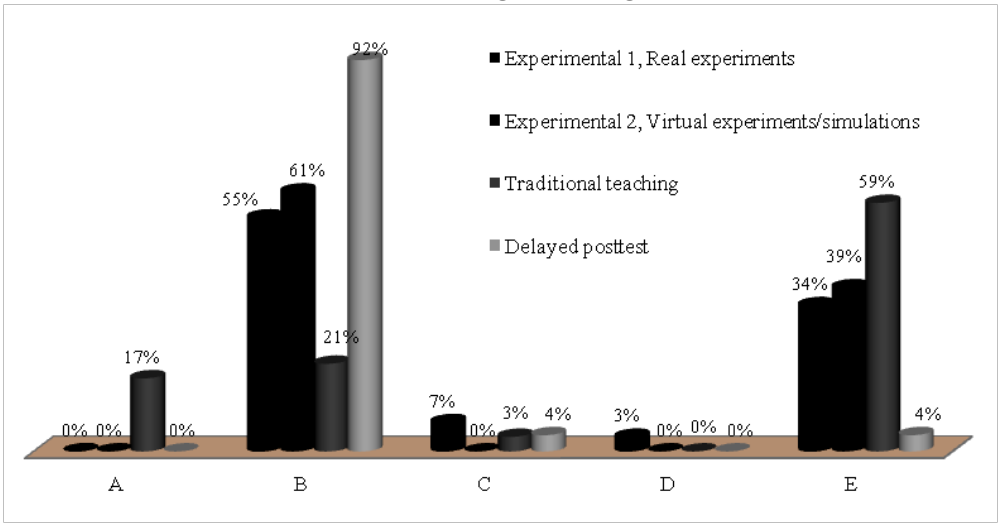


Fig. 2.

In order to answer correctly to this question the students have to know how the objects can be charged by induction and to apply this knowledge. As it can be seen from the graph,

there is a big difference between the experimental groups and the control one. Students from the experimental did much better result than the ones in the control group. Unlike in the first question, more students from the experimental group with computer simulations gave correct answer, compared with the experimental group with real experiments (61% compared to 55%). The simulation has the advantage compared to the real experiment that can make the invisible things visible. In this case the electrical chargers in the simulation are visible. Therefore, the simulation is not anymore only a tool for research, additionally it explains the phenomena. Better result can also be consequence of possibility for individual work. Each student could individually perform the experiment.

As it was the case in the first question, the delayed test shows big number of correct answers, around 92 %, bigger than at the posttest.

Similarly to the previous question was the following one:

One electroscope is negatively charged therefore its arrow shows a certain value on the scale. If a negatively charged rod is placed closer to the electroscope (without any contact), what will happen with the arrow of the electroscope? Draw the new situation!

The distribution of students answers are given in figure 3.

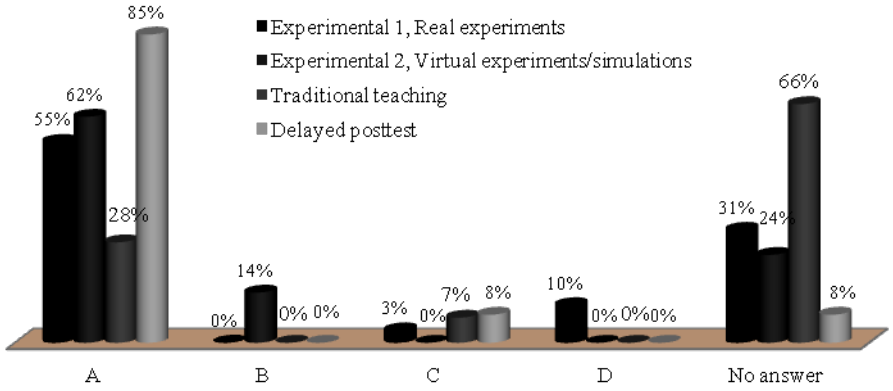


Fig 3: Legend: A – Increases; B – decreases; C – stays the same; D – will be zero

The results are similar to the ones in the previous questions. Here, the advantage of simulation, making visible the invisible things axplained in the previous question, is apparent again.. Again, the advantage of peer-to-peer discussion can be seen in the results of the delayed test.

4. CONCLUSIONS

The results from this investigation show that the teaching and learning approach applied with the experimental groups give better quality of knowledge and skills than the traditional one. Each of these approaches contributed differently, in the frame of characteristics they bring with them. For sure, they have overlapping of skills, like the development of the interacting and team work. The application of computer skills in teaching gives a better result in understanding

of some occurrences for which the student does not necessary need to deal with the technique. But, this is negatively reflected on the knowledge and skills related to the organization of investigation work in the laboratory, in building an experimental setup and solving practical problems. On the other hand, the real experiment pushes the students to think more in the first part of planning and preparing experiments

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