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Professional paper

THE IMPACT OF REAL AND VIRTUAL EXPERIMENTS ON THE UNDERSTANDING OF ELECTROMAGNETIC INDUCTION

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Abstract

In this research, we investigate the advantages and disadvantages of using real and virtual experiments in developing higher-order thinking skills. The target group was 12th-grade high school students (American System) conducted over three years 2019/2022/2023. The students were divided into three groups (classes): Virtual group, Real group, and Traditional group which were selected spontaneously. Real experiments were included in the classes of the Real group, virtual experiments were included in the classes of the Virtual group and traditional direct teaching was used in the Traditional group.
The virtual experiments can make the invisible things visible, by using PHET Simulations. This feature influences the students' understanding. On this basis, the students in the Virtual group have better answers and explanations than the ones in the Real group. The students in the real group compensate for the lack of visualization with the use of formulas, which in many times leads them to an incorrect answer. On the other hand, the research reveals that the students from the Real group can apply the acquired knowledge better than the ones in the Virtual group. The traditional group has a better understanding of the calculation part, but less in practical observation. However, the three methods are complementary in student's knowledge and skills.

Keywords: Electromagnetic induction, Virtual experiments, Real Experiments, American system, 12th grade students.

1. Introduction

Electromagnetic induction is a complex subject of physics that connects many laws and concepts from electromagnetism. When it comes to electromagnetic induction, students must integrate and apply their knowledge of the basic concepts of magnetic field, magnetic flux, Lorentz force, electromotive force emf, electric field, electric current, and electromagnetic force.

There is a considerable amount of research that focuses on understanding electromagnetic induction, but very little that focuses on how students understand it. Both" positive" and" negative" normative expectations active within a group may provide a foundation upon which to build and develop new norms and practices that more actively support the principles of the learning sciences (Ajredini, Izairi, & Zajkov, 2014). Normally, the connection of theory and practice would have a very large impact on the understanding of this phenomenon, excluding the interests and desires of students to understand it, if we speak generally of the sample we have used here.

The "American School of Kosova" (ASK) in Pristina regarding the natural sciences, as subjects has General Science which is taught in the 9th grade, Biology in the 10th grade, Chemistry in the 11th grade and Physics (Serway & Faughn, 2017) in the 12th grade. According to the curriculum, Electricity and Magnetism are taught in the second semester, almost for a month and a half and the last part of this chapter is Electromagnetic Induction. Physics is taught in English using the E-Book (Serway & Faughn, 2017), each lesson lasts 80 minutes and student evaluation is done with the American grading system (PowerSchool, 2005-2018), e.g. excellent are grades A+ (97-100 points), A (93-96 points), A- (90-92 points) and so on.

Physics is taught, we can say, for one academic year intensively. For students, the knowledge they receive during lectures, positively affects in understanding of physical concepts and their connection is closer to the things they need to remember. Therefore, the whole essence here is, how students absorb this knowledge, and with what methods used, we get to understanding and remembering the topics as well as the critical thinking skills and applications in real life, in our case about electromagnetic induction.

During this research, we noticed that the inclusion of computer simulations, (PhET, 2019); (Ajredini, Izairi, & Zajkov, 2014), plays a key role in a clearer understanding of electromagnetic induction, because everything can be visualized, such as the movement of electrons. During real experiments, we cannot see the movement of electrons, but we start from theory and imagine it as such, and in the case of PHET simulations we can even see it (Koopmans, 2010); (Flynn, 2011).

2. Methods and samples

2.1. The test: The prepared test was the same for all three classes and was held at the same time with a duration of 60 minutes. The point was to analyze the results based on the methods we have used and after that, we will try to use such a method as much as possible so that the purpose of teaching also works. The test is composed of questions requiring formal (conventional) knowledge and conceptual questions. In total, the test contained 20 questions (Serway & Faughn, 2017); (Polat, Ilhan , Konakli, & Sezgin, 2003), and all questions were multiple choice and some of the questions required the student to show their work before choosing the answer.

2.2. The sample: During the research of this paper, the 12th-grade students at the "American School of Kosova" were taken as a sample. This school is known as one of the best private schools in Kosovo and for this reason, the number of students is always limited the research has been done for three academic years (2019/2022/2023) to increase the number of students having this test, using the same methodology and techniques by the same teacher. Lectures, activities, and testing are done in English. Three classes per year, which were taken as a sample, had a total number of 175 students.

- The Traditional Class had 60 (2019-19, 2022-20 and 2023-21 students)
- The class with Real Experiments had 56 students – (2019-18, 2022-19 and 2023-19 students)
- Class with Virtual Experiments had 59 students - (2019-16, 2022-21 and 2023-22 students)

Based on the curriculum of the American education system, the part of the chapter on electricity and magnetism, in the subject of physics, is planned to be explained in the month of March-April and the finalization of all results took place in April of each year mentioned above.

3. Research results and discussion

We will discuss only 5/20 questions given in the test.
Based on the investigation of the progression in student understanding from introductory to advanced levels (Maries, Jane Brundage, & Singh, 2022) and according to Bloom's Taxonomy we have chosen some questions as below.
Question 1 starts with Level 1-2 of Bloom's Taxonomy, in order to see how students understood the concept of electromagnetic induction.
Question 1: Name the phenomena in which a current induced in a coil due to change in magnetic flux linked with it:

a. Electromagnetic induction
b. Magnetic Force
c. Current flowing
d. None of the above

The results of this question are represented with the Figure 1.

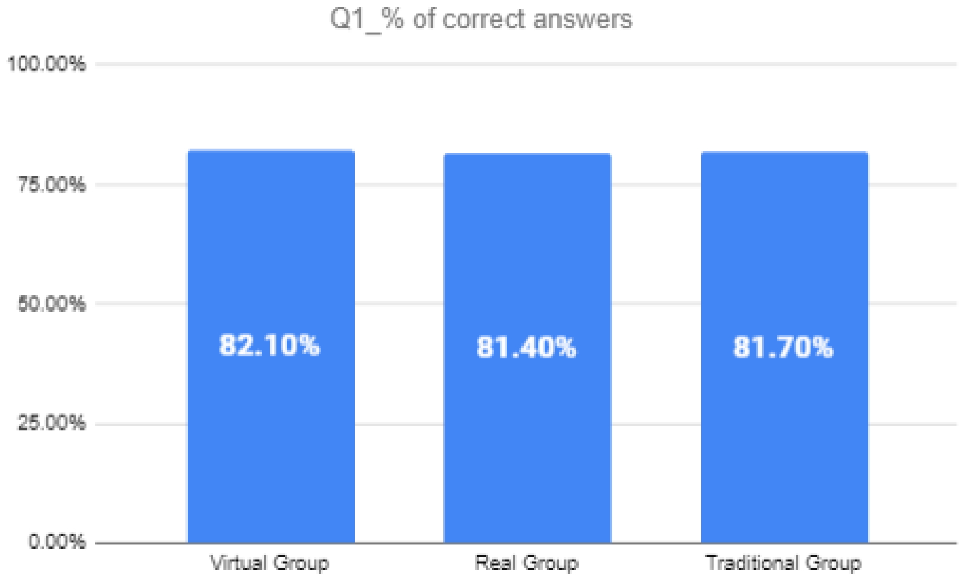


Figure1. The Percentage of correct answers for question 1.

The question falls under the category of Level 1 in Bloom's Taxonomy (Patricia & Trent, 2007), which focuses on the knowledge level of understanding. The results across all three groups – Virtual (82.10%), Real (81.40%), and Traditional (81.70%) indicate a high level of proficiency in answering this question correctly. This suggests that students in each group possess the foundational knowledge required to identify electromagnetic induction as the phenomenon responsible for inducing a current in a coil.

To find out how students know that emf from what depends on, which represents a question of level 2-3 of Bloom's Taxonomy, we have introduced the question in the form such as below:

Question 2: A magnet is moved in and out of a coil of wire connected to a high-resistance voltmeter. If the number of coils doubles, the induced voltage:

1. Is the same
2. Doubles
3. Quadruples
4. Halves
5. None of the above

Based on this question, the results of the correct answers are given in the Figure 2.

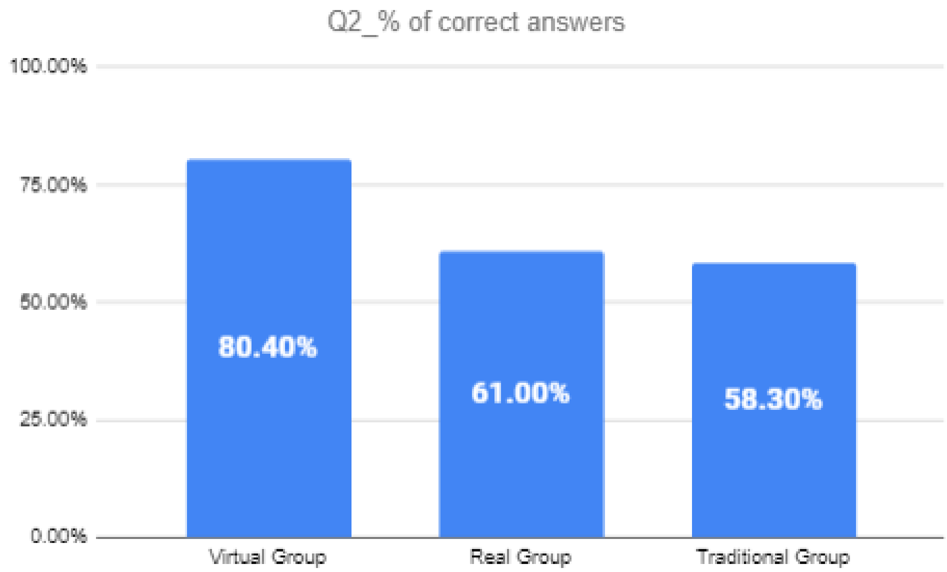


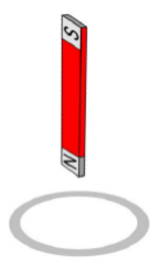
Figure 2. The Percentage of correct answers for question 2.

The findings reveal a significant difference in the performance of the three groups regarding understanding and achievement. In the Virtual group, 80.4% of the students demonstrated improved understanding and higher scores. In the Real group, 61.00% of the students showed enhanced understanding and achieved commendable scores. However, in the traditional group, only 58.30% of the students exhibited improved understanding and achieved satisfactory scores. This highlights the effectiveness of virtual experiments in promoting better comprehension and academic performance compared to real experiments and traditional teaching methods (Chini, Madsen, Gire, Rebello, & Puntambek, 2012).

To see how students can apply understanding and knowledge from lower levels of Bloom's Taxonomy to higher levels, in our case Lenz's Law for the direction of current flow, we have set questions 3 and 4 as below:

Question 3: A bar magnet with a north pole facing down is dropped above a conducting ring. As the magnet passes through the ring, what is the direction of the induced current in the ring?

a. Always clockwise
b. Always counter clockwise
c. First clockwise then counter clockwise
d. First counter clockwise then clockwise
e. No induced current in the ring



Based on the question above, the Figure 3 shows obtained results:

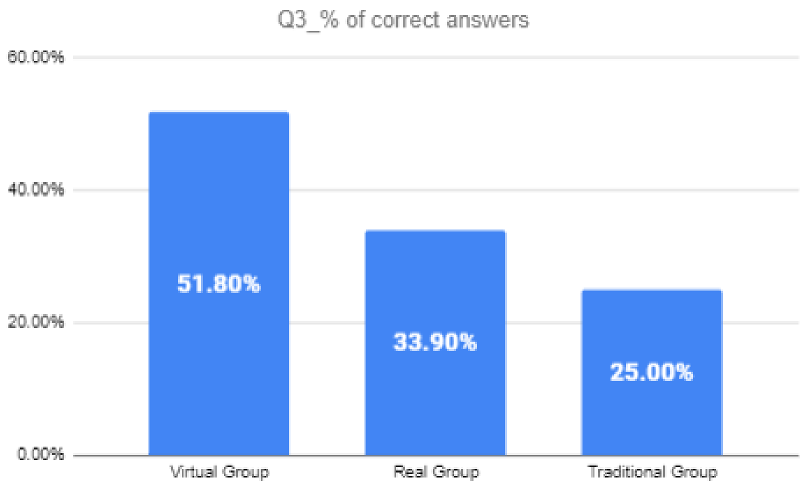
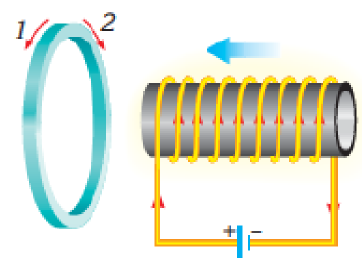


Figure 3. The Percentage of correct answers for question 3.

These findings suggest that both virtual and real groups were effective in helping students grasp the concept of the induced current's direction when a magnet passes through a conducting ring. The visualization provided by these methods likely contributed to a better understanding among students, leading to higher accuracy rates. Conversely, the Traditional group, which relied on more traditional teaching methods, displayed a relatively lower level of understanding in this particular aspect.

Question 4: If the solenoid is brought near to the circular loop. What will the direction of the induced current on the loop be? Explain your answer.

a. 1st direction
b. 2nd direction



The results based on the test are shown in the Figure 4 below:

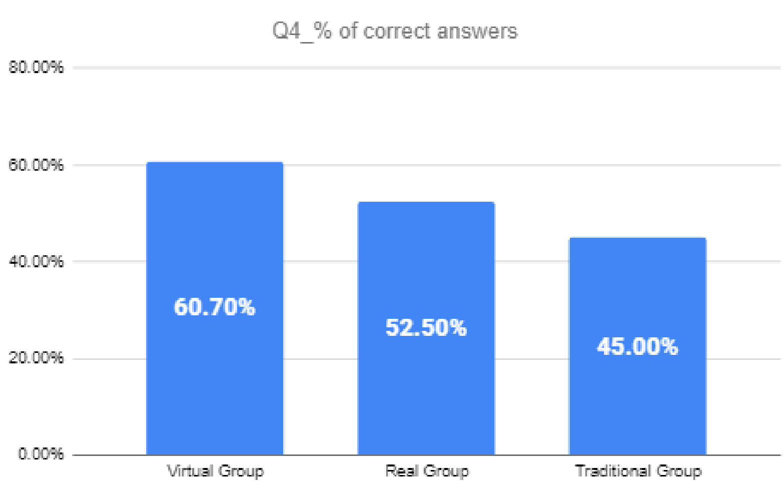
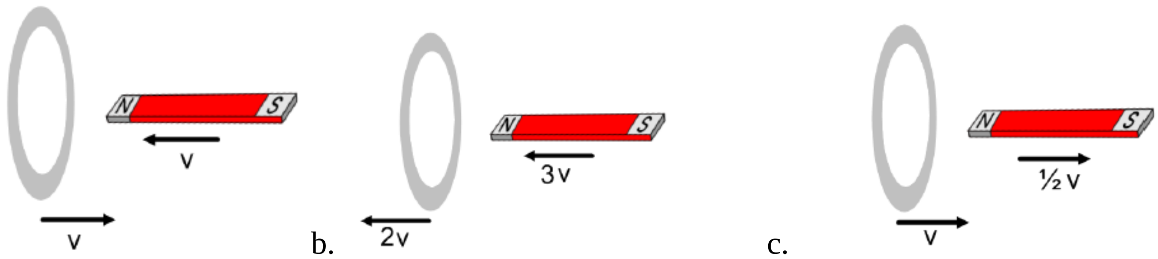


Figure 4. The Percentage of correct answers for question 4.

In this question, we have observed variations in the performance of the three groups in determining the direction of the induced current. The results indicate that the Virtual group performed a 60.70% accuracy rate in providing the correct direction of the induced current. In comparison, the Real group had a 52.50% accuracy rate, while the Traditional group had a relatively lower success rate of 45%.

To see how students can apply understanding and knowledge from lower levels of Bloom's Taxonomy to higher levels, in our case Faraday's Law for electromagnetic induction, we have set the question as below:

Question 5: The induced current in the closed loop is largest in which one of these diagrams? Show and Circle.



The results of this question are shown in the Figure 5 below:

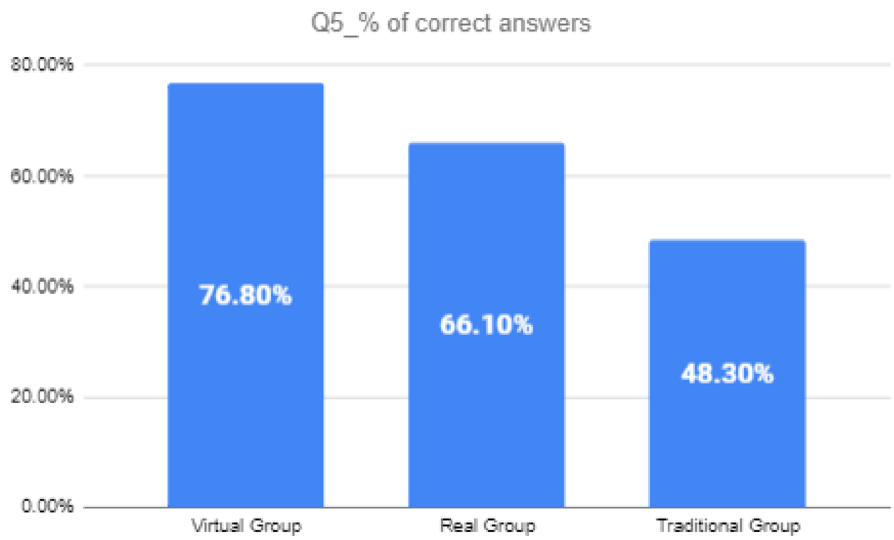


Figure 5. The Percentage of correct answers for question 5.

This question requires knowledge of the highest levels, especially analysis, synthesis, and evaluation. This question requires previous information related to Motion. Since the induced emf, or the induced current, depends on the speed of the change in magnetic flux, this means that the faster it moves, the greater the change in the magnetic flux will be, so the induced current. From the graph, it is clear that better results were achieved by students in classes where real and virtual experiments were used.

4. Conclusion

Based on the final results of the students of each class, we managed to understand the impact of each method on the expected results.
The research shows that each of the approaches gives a different contribution to the knowledge and understanding of the processes and concepts of Electromagnetic Induction. Real experiments contribute to the skills related to cooperation and teamwork, as well as to better understanding of the phenomena. On the other hand, simulations give opportunity to the students to spend more time thinking about the results, phenomena, and relations (Beer, 2010).
One of the most essential advantages must be deeply considered by the teachers, possibly to perform virtual experiments as homework (Flynn, 2011); (Finkelstein, et al., 2005). However, the two methods are complementary in developing student's knowledge and skills.

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