ANALYSIS OF THE IMPACT OF VIRTUAL SIMULATORS IN PHYSICS CLASSES IN GENERAL SECONDARY EDUCATION

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Abstract

The current study entitled Analysis of the Impact of Virtual Simulators in Physics Classes in General Secondary Education. This study aimed to analyze the impact of virtual simulators on physics lessons in secondary education, understand the effects of these tools on the learning of physics concepts, and seek indications of a learning theory to investigate its applicability. From this point of view, we were interested in finding new and different ways of expressing physics knowledge, in other words, a modern methodology, both from a pedagogical and technological perspective. It is based on these assumptions and taking into account the competencies and skills that students will be able to develop in the subject of Physics in secondary degree school (ES2), that the following key question was formulated: How can virtual simulators transform the teaching-learning process in grade 12 on physics lessons? The research was conducted at the Ponta-Gêa General Secondary School, located in Beira City. The methodology adopted was action research, allowing the active participation of students and teachers in the research process. The target population included grade 12 students and physics teachers. The sample consisted of 16 (sixteen) students and 1 (one) teacher. Data was collected through questionnaires, interviews, and direct observations. The virtual simulators used included the Algodoo software, known for its interactive and educational capabilities. Data analysis combined quantitative and qualitative methods, using statistical tools and content analysis. The results indicated a significant increase in student engagement and understanding of physical concepts, suggesting that the integration of virtual simulators may be a viable solution to the lack of physical laboratories.

Keywords: Virtual Simulator, Algodoo, Physics, Meaningful Learning

1 INTRODUCTION

The teaching of physics in secondary education faces significant challenges, especially in contexts where there is a lack of teaching laboratories. The difficulty in visualizing and experimenting with complex physical concepts limits student's understanding and engagement with the subject. The introduction of educational technologies, such as virtual simulators, can offer an innovative alternative to overcome these limitations. Ausubel's Theory of Meaningful Learning suggests that new knowledge is more effectively assimilated when connected to previously existing concepts in the students' cognitive structure [1].

For [1] the storage of information in the human brain occurs in an organized way, in which a conceptual hierarchy is formed, in which more specific elements of knowledge are linked and assimilated to more general and inclusive concepts, as mentioned in [2]. However, we can affirm that the new knowledge is not disbursed in the student's cognitive structure, that is, when it is distributed, it is linked to the subsuming concepts.

However, according to [3] machine learning is that in which the subject memorizes new knowledge as if it were information that may not mean anything to him, but that can be reproduced in the short term and automatically applied to known situations. In the context of the technological trends in which we live, simulations in computer environments gain space in educational research, as they allow teachers to reconcile their didactic experiences with the use of technologies integrated into their pedagogical practices in order to promote potentially meaningful learning [4].

Previous study highlights the benefits of virtual simulators in science education. [4] in his research on The Cotton Software as a Potentially Significant Material for the Teaching of Physics: Simulations and Possible Conceptual Changes, sought to verify the adequacy and understanding of physical phenomena related to science and dynamics through the production and application of virtual simulations, and found that: *"... The use of simulation software in the classroom can contribute to the construction of scientific* *knowledge when used with appropriate pedagogical practices, also contributing to the change of the student's posture in the classroom, making them more active and critical in the face of questions".*

In the Curricular Plan of General Secondary Education [5] it is stated that the learning of Physics in the 2nd cycle aims to broaden and deepen the knowledge acquired in the 1st cycle so that, the student can understand the evolution of technological means and its dynamic relationship with the evolution of scientific knowledge. At this level, the learning of Physics aims to develop in student's skills that allow them to articulate physical knowledge with knowledge from other areas of scientific knowledge, build physical models and use them to analyze and explain natural phenomena and everyday situations; Examine and illustrate physical models using information and communication technologies, among others.

This study aims to investigate how virtual simulators can influence physics learning, improving understanding of concepts and student engagement. The main objective is to evaluate the effectiveness of virtual simulators as a complementary tool in physics teaching.

2 METHODOLOGY

The research was conducted at the General Secondary School of Ponta-Gêa, located in the city of Beira. The methodology adopted was action research, allowing the active participation of students and teachers in the investigation process. The target population included 12th grade students and physics teachers. The sample consisted of 16 (sixteen) students and 1 (one) teacher. The data were collected through questionnaires, interviews and direct observations. The virtual simulators used included the Algodoo software, known for its interactive and educational capabilities. The data analysis combined quantitative and qualitative methods, using statistical and content analysis tools.

Educational software is a computer program designed and built from several executable ordered commands, providing a range of interactive activities for the user [6]. The choice of software, in addition to being fundamental for the work that the educator will develop with his students, presupposes a vision of the world, a conception of education. This shows the importance that should be given to the choice of programs that will be selected to be used for educational purposes.

In this perspective, we will make an exposition of the properties of ray propagation in homogeneous media, with emphasis on optical phenomena such as: reflection, refraction, absorption, transmission.

When dealing with the topic of ray optics, also known as geometric optics, we do not take into account the wave-like character of light, nor its polarization [7]. Under these conditions, effects such as diffraction and interference are not evident.

3 RESULTS

In an attempt to answer the question of this study: What impact did virtual simulators have on practical physics lessons in grade 12? Two questionnaires were drawn up after the experimental lessons using the virtual laboratory, with the aim of obtaining more information about the satisfaction, understanding, motivation and interaction of the target audience, compared to what has observed in traditional classroom models. The answers given by the students were analysed, along with the observation of their attitudes and reactions during the application of the activities.

In order to obtain the data for this survey, information was collected from sixteen students and one teacher from (1) class in the 12th grade at Ponta-Gêa Secondary School, showing each question asked in this survey. The main objective of each one, and the results that present the data from the individualised opinions that contributed in a general way to the statistical survey to which a quantitative-qualitative survey is proposed.

For each activity, we analysed the contents. The analysis covered two different moments: before using the simulator, which aimed to make the student think about the question with their previous knowledge, helping to organize the subsumers, and post-simulation activities, where we hoped to observe the systematization of the content worked on with the educational product.

For each activity, we classified the moment it fits, presented the content analysis, and discussed the result. To preserve the identity of the research subjects, the names of those involved in the questionnaire have not been mentioned. It should be noted that before the activities were carried out, the students were given a demonstration for a few hours to learn how to use the main functions of the Algodoo software.

3.1 Statistical Data-Students

The results of this research show that the use of virtual simulators led to a significant increase in student engagement and understanding of physics concepts. For instance, the students were given an exercise to calculate the time(s) in which the pendulum performs a complete oscillation, taking into account that the length is 2.5 meters. When solving the simple pendulum problem in the traditional method (pen and paper) the students followed the next steps:

Step1 - Identify the equations: in this case, the pendulum has a length of 2.5 meters and a maximum amplitude of 0.5 meters. The acceleration of gravity was considered to be approximately 9.8 m/s². These values were then replaced in the form.

Step 2 - Manipulation of equations: Simplify equations, solve systems of equations, and perform mathematical calculations necessary to obtain the final solution.

On the other hand, when using the cotton simulator, there was a more practical and visual approach to solve the problem such as pendulum configuration, definition of physical laws, simulation and analysis The simulator provided information about the position, velocity, and acceleration of the pendulum over time and analysis of the results.

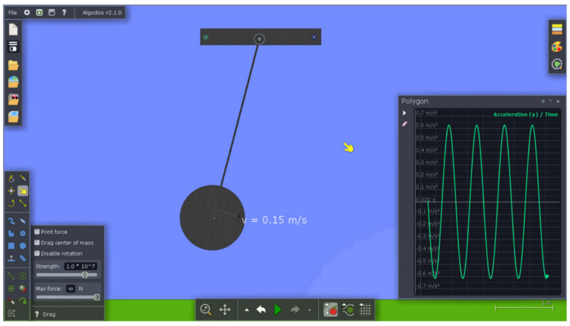

Figure 1: The Pendulum falls at a speed of 0.15m/s

The interpretation of the static data and responses obtained allows us to analyze the results obtained to verify the need to modify or improve the way of applying this type of tool in the physics teaching process.

3.1.1 Students Perspective

With regard to the level of acceptance and motivation of physics classes through the use of the virtual Algodoo simulator. More than 93% of the students said that to felt more motivated to learn the contents of the class through the use of the simulator. Although the remaining 6.2% were indifferent to this question. Based on these statistical indicators, we can affirm that the cotton simulant was accepted by the majority of students.

In terms of the relevance of the interaction between students and teacher during class, 56% of the respondents agreed that the interaction with the teachers was helpful. Since teacher facilitated in the perception of the contents covered in class, 12.5% totally disagreed, 25% were indifferent and the remaining 6.2% partially disagreed. In this context, we can conjecture that the interaction between students and the teacher during classes is pertinent, taking into account that it helps in the process of assimilation of the contents.

Many students had the opportunity to use virtual simulators for the first time. The expression of curiosity and enthusiasm in exploring complex physical concepts in an interactive way was a highlight. Through Algodoo, students were able to visualize and manipulate simulations that were previously only theoretical.

Several students reported amazing moments when concepts that seemed abstract suddenly became clear. Visualizing Newton's laws in action or understanding the conservation of energy through the simulations were particularly impactful. They expressed gratitude for having had the opportunity to learn in a more interactive and visual way. Some mentioned that they felt more prepared and confident to face exams and future academic challenges.

3.1.2 Teacher perspective

The professor reported that the introduction of virtual simulators revitalized his teaching practices. They appreciated the possibility of explaining concepts more clearly and seeing their students more engaged and interested in physics classes.

Comparing the data obtained with the existing literature, the results corroborate with previous studies that highlight the benefits of educational technologies in science education. Those studies concluded that the systematic use it in the classroom has a new way of teaching physics, where phenomenological perception is no longer possible only through experiments and mathematical modeling, but through interaction with dynamic and interactive models.

4 CONCLUSIONS

The study found that, virtual simulators have a significant positive impact on physics learning in secondary education. The integration of these technological tools, can improve understanding of concepts and increase student’s engagement, especially in contexts where there is a lack of physical laboratories. The objectives of the study were achieved, demonstrating that virtual simulators are a viable and effective solution to overcome the limitations of traditional physics education. It is recommended that these technologies be continuously implemented in schools and that teachers be trained to optimize their use.

Teachers have noticed a significant increase in student engagement and participation during lessons. Interactive simulations made physics lessons more dynamic and stimulating, encouraging students to ask questions and explore the topics discussed further. The application of virtual simulators contributed to the improvement in the academic performance of students. There was a noticeable improvement in test scores and assessments, reflecting a better understanding of physical concepts.

The use of virtual simulators helped students develop critical thinking and problem-solving skills. By manipulating variables and observing the results, students learned to formulate hypotheses, test their predictions, and adjust their understandings based on the observations. The implementation of the simulations often required collaboration between students. Group work to solve complex problems strengthened teamwork skills and communication among students.

However, we emphasize the risks of using computer simulators as if they formed a "virtual laboratory" that could replace real experiments, which are the ones that require the most time and cost in their execution. A computer simulation does not constitute a laboratory experiment, since, most of the time, it is a simplification of how nature behaves.

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