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Utilities of Computer Simulations in Physics Instructional Transaction

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Abstract

It has always been a herculean task to make teaching and learning much more interactive, engaging, and interesting. So researchers have always been directed to make every effort in this direction as at the core of every teaching and learning process are our future citizens, the students of today. Physics teaching and learning requires to be even more interactive, engaging as the concepts are abstract. So computer simulations are such tools that are capable of transforming the complete landscape of physics education. They replicate the real phenomenon and are represented through computer programs. So this paper includes the definition and uses of computer simulations alongside the use of computer simulations in physics instruction.

Keywords: *Computer simulations, Physics, Physics instruction, Utilities.*

Introduction

Most science requires innovative ways of teaching as lecturing has proved to be ineffective when it comes to science teaching. Physics is one of the branches of science that has a lot of abstraction and proves to be a subject that pertains to a lot of demonstrations and experimentation. But all the time availability of physical labs is a hindrance due to the scarcity of equipment and other resources. In such scenarios, computer simulations may prove to be an effective tool for teaching physics. Researchers across the world have always fantasized about computer simulations for teaching engineering, biology students. But very few studies were found to have given due importance to computer simulations in teaching physics.

In the backdrop of the above arguments, and most of the papers reviewed after 2015 onwards discussed computer simulations in contexts of science teaching, biology teaching but this study delves into teaching physics through computer simulations.

Review of related literature

Computer simulations are based on the constructivist epistemology of learning. They are a connection between phenomena and theory and provide an abstract representation for the students to base their measurements on. Additionally, simulations that are based on scientific theory give the students experiences that challenge their informal understanding of science (Richards, Barowy, and Levin, 1992).

These simulations are representations or models of some events, objects, or phenomena (Thompson, Simonson, and Hargrave, 1996). But in science education, simulations simulate a dynamic system of objects in real and imagined worlds (Akpan, and Andre, 1999). In an educational context, Alassi and Trollip (1991) described simulations as:

"A simulation is a powerful technique that teaches about some aspect of the world by imitating or replicating it. Students are not only motivated by simulations but learn by interacting with them like the way they would react in real situations. In almost every instance, a simulation also simplifies reality by omitting or changing details. In this simplified world, the student solves problems, learns procedures, comes to understand the characteristics of phenomena and how to control them, or learns what actions to take in different situations."

By this Alassi and Trolip (1991) stressed that computer simulations are the replica of the real-world phenomena that is in simplified form. The students interact with these as they would do in real situations.

Sahni (2006) suggested that the success of computer simulations depends a lot on the way they are incorporated into the curriculum and the way teachers use them in the classrooms. They further added that the most appropriate way to use them as supportive tools to classroom instruction and lab activities. In line with these, they additionally propounded that computer simulations are capable of creating a constructivist environment as they are multimedia supported, highly interactive and students can work collaboratively with these. Computer simulation-enabled environments support inquiry learning, scaffold learning by providing cognitive tools and applying problems. They are also useful in distance learning.

Additionally, Pfefferová (2015) found that simulations positively affect the knowledge level of the students and enhances achievement in physics. Simulations are effective in bettering the understanding of physics laws and students can creatively solve tasks that require a combination of knowledge from different fields of education. It was also pinpointed on the diverse simulations that are available on the internet but require dedication and time to find suitable simulations. Further, it also stated that simulations can be used as innovative teaching methods. But it was also revealed that replicates do not impact students working with the graphs.

In line with these, Mengistu and Kahsay (2015) added that simulations aids in mastery abstract concepts very easily and student achievement rises when simulations are used interactively as an aid to classroom instruction. The students understand the concepts well. Additionally, students were more satisfied with the instruction imparted to them and found the teaching material on electric fields and electric forces to be more engaging. Furthermore, they make abstract concepts highly visualizable. These observations were recorded during the study on the use of simulations as an aid to classroom teaching of electric fields and electric forces.

On the same lines, Aoude (2015) proved that a computer simulation greatly enhances the achievement of the students apart from equipping them with procedural knowledge. In addition to this, students of medium and low ability groups comparatively were more benefitted than the high ability grouping students.

Alongside, Ouahi, Hou, Bliya, Hassouni, and Al-Ibrahmi (2021) found that simulations positively impacted the performance of the students, refined their understanding, and reduced certain learning difficulties that they had. The simulations are equally effective for male and female students but rural student's performance was below that of the urban students.

These reviews have been summarized in Table 1.

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Table 1: Literature on computer simulations in physics education

Author	Year	Statement about simulations
Pfefferová	2015	Better knowledge level, enhance performance
Mengistu and Kahsay	2015	mastery abstract concepts make learning material more engaging
Aoude	2015	procedural knowledge
Ouahi, Hou, Bliya, Hassouni, and Al-Ibrahmi	2021	Increase performance, refine understanding

Questions to be addressed

1. What are computer simulations?
2. What are the uses of computer simulations?
3. How are they useful in Physics teaching?

Methodology

In this qualitative study, secondary data has been collected from databases such as Eric, ResearchGate, Academia, Science Direct, Springer, and Elsevier. Here research papers have been reviewed from 2015 onwards as evidence to support the study. The keywords fed to search the review of the literature were "computer simulations and science teaching", "computer simulations and physics teaching and learning". Review papers and meta-analyses have been excluded from the study. Papers published in journals, thesis, dissertations have been reviewed for the paper. On reviewing the literature, the following themes emerged: Definition of computer simulations uses of computer simulations, the usefulness of computer simulations in science teaching.

Findings and discussion

1 Definition and uses of computer simulations

Computer simulations are a model or a replica of an object, event, or phenomenon. These are just the simplified representations of complex phenomena or processes that may include animations, videos, and audio. These are computer programs. The students can learn procedures, solve problems in such environments. They give the students real experiences that are similar to real-world experiences. The students also learn and understand various aspects of the phenomena like their characteristics, how to control them, and at the same time learns the various actions that need to be taken to suit the changed circumstances.

2 Usefulness of computer simulations in physics education

Computer simulations are very effective in reducing the abstract concepts that are an inherent part of physics (Steinberg, 2000; Redish, 1990). They being highly interactive keeps the students intact with the learning material and the student actively constructs the knowledge. They enhance achievement in physics, give the students procedural knowledge, and refine their cognitive abilities. Although they are very effective in increasing the understanding but finding a suitable simulation of the phenomena needs devoted efforts and time in searching on the internet. These simulations do not discriminate among the genders and are equally beneficial for all. But urban students were found to be outcasts of their rural counterparts. This may be attributed to the unavailability of facilities, power cuts, and low availability of internet services. Simulations are equally effective in overcoming the learning difficulties in physics. Further, they support inquiry learning and scaffold learning.

Conclusion

Computer simulations though in existence for a very long but not in use either due to unawareness or lack of training of teachers. But giving their benefits for teaching science in general and physics, in particular, must be used as a supplement to classroom instruction. It is because they are making the teaching-learning material more engaging, provides various representations of the phenomena thus reducing the abstractness in the concepts. Even more, they are far more motivating and enhance the performance of the students, give them ample opportunity to learn constructively by being actively engrossed in their learning process and building knowledge basing the foundation on the previous background. These simulations can be accessed from any time and anywhere so also very helpful in distance learning. These can also be used pre-lab activities before entering the real labs that will make the students aware of the instruments being used. This will enable them to work efficiently with the instruments. So computer simulations must be used in physics education as much as possible.

Suggestions for further research

Computer simulations could be used for problem-solving in physics that is an inherent feature of physics education and physics cannot be devoid of problem-solving. So researches could be carried on this. More and more simulations could either be translated or created in vernacular languages giving the diversity of India.

References

Akpan, J. P., & Andre, T. (1999). The Effect of a prior dissection simulation on middle school students' dissection performance and understanding of the anatomy and morphology of the frog. Journal of Science Education and Technology, 8, 107-121. Retrieved December 2nd September 2021 from http://ipsapp008.kluweronline.com/content/getfile/4947/1/2/fulltext.pdf

Alessi, S. M., & Trollip, S. R. (1991). *Computer-Based Instruction: Methods and Development.* New Jersey: Prentice-Hall.

Aoude, M. F. N. (2015). The impact of integrating computer simulations on the achievement of grade 11 Emirati students in uniform circular motion. Masters thesis, United Arab University

Mengistu, A., & Kahsay, G. (2015). The effect of computer simulation used as a teaching aid in students' understanding in learning the concepts of electric fields and electric forces. Latin American Journal of Physics Education, 9(2), 24021-24028. Retrieved from https://dialnet.unirioja.es/descarga/articulo/5509790.pdf

Ouahi, M. B., Hou, M. A., Bliya, A., Hassouni, T., & Al-Ibrahim, El-Mehdi (2021).the effect of using computer simulation on students' performance in teaching and learning physics: are there any gender and area gaps? *Education Research International*, 2021, 1-10. https://doi.org/10.1155/2021/6646017

Pfefferová, M. S. (2015). Computer simulations and their influence on students' understanding of oscillatory motion. *Informatics in Education, 14*(2), 279-289. DOI: 10.15388/infedu.2015.16

Redish, E. (1990). Millikan award lecture, building a science of Teaching Physics. *American Journal of Physics, 67*, 562-573.

Richards, J., Barowy, W., & Levin, D. (1992). Computer simulations in the science classroom. *Journal of Science Education and Technology,* **1,** 67–79. https://doi.org/10.1007/BF00700244

Sahin, S. (2006). Computer Simulations in Science Education: Implications for Distance Education. *Turkish Online Journal of Distance Education, 7*(4), 1-13. https://files.eric.ed.gov/fulltext/ED494379.pdf

Steinberg, R. (2000). Computers in teaching Science: To simulate or not to simulate? *American Journal of Physics, 68*, 37- 41.

Thompson, A., Simonson, M., & Hargrave, C. (1996). Educational technology: A review of the research, 2nd ed. Washington, DC: Association for Educational Communications and Technology.