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Studying the Influence of Computer Simulation on Student Engagement: A Literature Review

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***Abstract*—*This literature review aims to study the usefulness of incorporating digital simulation technologies into instructional settings, with a particular focus on the impact that this technology has on the outcomes of students' educational endeavors and the ways in which it shapes their perspectives of those outcomes. In addition, in order to connect earlier studies on individual behaviors with simulated computer technology, it is essential to highlight literature on the application of simulations using computers along with determining literature gaps regarding the efficacy of the various types of simulation in improving student learning outcomes. Doing so will allow for the connection of earlier studies on individual behaviors with simulated computer technology. Both of these steps are essential in order to connect previous studies on individual practices with computer simulation technology. Engagement of Students refers to the extent of students' interest, involvement, and participation in the learning process. Engaged students are more motivated, attentive, and invested in their education, making it a crucial component of effective teaching and learning. Students are more likely to acquire knowledge, develop skills, and attain positive learning outcomes when they are engaged*.

***Keywords*—** *Computer, influence, engagement, simulation, student*.

I. INTRODUCTION

The most recent few years, there has been a notable rise in the number of classrooms that use computer simulation technology, and it is projected that this pattern will continue. Incorporating computer simulations into the classroom has been shown to improve students' learning outcomes and provide educators with valuable tools to promote scientific inquiry among students. According to a study by Eun and Youn (2017) that focused on cooperative learning activities involving simulations, simulations enable students to gain first-hand experience investigating problems from multiple perspectives, which contributes to improved academic performance, communication skills, and overall grades. In this section of our investigation, we will center our attention on the usefulness of technology-based simulator technology in an educational setting, as well as the types of information that students are able to gain in using these technologies.

Advancement in digital information technologies have contributed to the creation of a variety of computer simulations. This development is a logical response to the evolution of information and communication technology, which includes the utilization of virtual laboratories, as Saputri (2021) notes.

Integration of computer simulation technologies into science education has been demonstrated to improve student learning. Such simulations produce an interactive, hands-on learning environment that facilitates students' comprehension of complex scientific concepts. In STEM disciplines such as science, technology, engineering, and mathematics, degree-seeking students must work with complex models that depict real-world systems. According to Kutz, Brunton, Brunton, and Proctor (2016), gaining expertise in managing these complex systems, which involve numerous variables and interactions, requires specialized training. Students aspiring to excel in STEM disciplines must enroll in accredited programs, regardless of whether they will be working with supply chains, infrastructure structures, communication networks, or computing systems. By utilizing computer simulations, students enrolled in STEM courses can acquire the necessary skills to navigate these complex systems, thereby contributing to field advancements and nurturing overall development (Tirol, 2022).

Computer technologies have the potential to revolutionize education by expanding the options available to instructors and fostering closer collaboration among students, their peers, and subject matter experts. It is possible that this will result in a significant improvement in the overall quality of learning. As stated by Etin (2018), the use of ICT, which stands for information and communication technology, within the educational setting is meant to encourage the creation of instructional procedures that are both efficient and successful. In the context of online education, simulations provide a viable solution for addressing the dearth of process skills in the natural sciences, an issue that has become more prevalent as online education has gained popularity (Tinapay & Tirol, 2021). Saputri (2021) notes that simulations allow students to engage in remote collaborative activities with real-world applications in the laboratory.

II. LITERATURE REVIEW AND DISCUSSIONS

Computer Simulation in Student Learning Outcomes

By employing computer simulations, a wide range of ideas and processes can be modeled in various ways. As highlighted by Jimoyiannis and Komis (2017), simulations serve as a link

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between students' prior knowledge and the acquisition of new physical concepts. They also actively support students in rectifying any misconceptions they may have, fostering comprehension throughout the lesson. According to Abdulwahed and Nagy (2016), one highly effective approach to enhance the utility of computer simulations is to integrate them with hands-on activities in a course. This combination has shown promising results.

Simulations created by computers provide imagined, changing, and graphical depictions of actual occurrences and trials that could prove too dangerous, costly, or inconvenient to conduct in a classroom laboratory. Simulations like these are easily accessible on personal computers of the present day. Computer simulations offer students the opportunity to investigate possible scenarios, engage with simpler versions for processes along with systems, manipulate the timescale of occurrences, procedures tasks, and address issues within an authentic setting with no experiencing tension (Abdulwahed and Nagy, 2016). In addition, students can engage in all of these activities stress-free.

Benefits and Advantages of Using Simulations in Science Classrooms

Teachers introduce theoretical concepts and supplement their explanations with computer simulations to improve students' comprehension (Bowling & DeLuca, 2015). This instructional method is still extensively employed in numerous classrooms. Conceptual simulations are employed in these classrooms to engage learners through research activities within the simulated environment. Participation in conceptual simulations challenges students to think critically and rewards them with improved learning outcomes. By manipulating simulation variables, students can observe the effects of their changes, thereby enhancing their understanding as they acquire command over the variables (Tirol, 2023). According to Chen et al. (2014), they have concluded that interactive and dynamic simulations on computers, which allow learners to participate as well as immersion, have an effect on the outcomes of learning that is comparable to or even greater than that of text and static visuals. This conclusion was reached after the researchers compared the effectiveness of these two types of learning tools. Research carried out by Chen, Chang, Lai, and Tsai lends credence to the aforementioned conclusion.

Utilizing simulations powered by computers in science instruction has many advantages. These include the easy availability of simulators to learners, the incorporation of useful limitations, the availability for productive as well as immediate feedback regarding the presentation for complex ideas, and the possibility of enhanced concept recall. In the field of earth science, for instance, where it is not possible to modify the quantity of greenhouse gases in the atmosphere for experimental purposes in a physical facility due to the variability of these gases, computer simulations provide a practical solution. In addition, hands-on laboratories can place substantial financial strains on educational institutions. Nonetheless, Finstein, Darrah, and Humbert (2013) concluded that secondary school learners perform equally well in simulated and physical laboratories during general physics instruction. Therefore, institutions can teach scientific subjects virtually, even if they lack the resources to establish a conventional laboratory.

Chen et al. (2014) established that applications developed on computers work well in conveying each complex ideas and the extremes of them. Moreover, it has been discovered that simulations that allow students to conduct experiments multiple times improve retention rates. Providing students with more time for repetitive experimentation would result in a deeper comprehension as they conduct more evaluations. Due to the simplicity of resetting the simulation, Renken and Nunez (2013) discovered that students were inclined to complete multiple simulation trials. Therefore, providing students with additional opportunities for experimentation can considerably enhance their comprehension of the subject matter.

Disadvantages and Limitations of Science Classroom Simulations

In accordance to de Jong, Linn, and Zacharia (2013), one of the drawbacks of using computer simulations is that users are unable to physically interact with the laboratory equipment in the same way that they would in a conventional laboratory. Efforts are being made to address this drawback by incorporating virtual versions of equipment and instruments as technology advances. Additionally, unlike traditional experiments, computer simulations do not account for measurement errors or unexpected occurrences (de Jong et al., 2013). Chen et al. (2014) note that students often hold an idealistic view of technology, assuming that all data generated by simulations is accurate. Consequently, they may lack a critical perspective when interpreting simulation results. To ensure students have a meaningful learning experience in simulation-based environments, it is important to provide access to real-world data and expose them to realistic conditions rather than idealized scenarios.

Renken and Nunez (2013) observed that their approach, which involved providing guidance during simulations, did not contribute to an improvement in participants' conceptual understanding. This finding highlights the need for caution when using computer simulations and suggests that careful consideration should be given to the instructional strategies employed.

Utilization of Computer Simulations in Education

The use of technological simulations highlights the participation of the students as active agent in terms of the development of knowledge. Previous studies (Vlachopoulos & Makri, 2017) have shown that simulations have the potential to shape participants' learning expectations. According to Lindgren et al. (2016) simulation-based literacy doesn't only focus on the aspects of improving learners' cognitive comprehension on the taught lesson, as well as to increase their engagement and motivation to construct new knowledge, thereby nurturing new learning experiences. In addition, it was discovered that computer simulations can enhance the cognitive and emotional literacy of learners in various

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disciplines, thereby increasing their learning satisfaction and engagement (Lee et al., 2021).

Simulation laboratories have become a prominent feature in modern educational institutions, particularly those catering to nursing, health, and medical students. Rooney (2018) highlights that these simulation spaces provide literacy skills that bridge the gap between professional education and work, offering a valuable learning environment for health professionals. According to Shin et al. (2015), which investigates with the use of meta-analysis that has a focus on the effects of patient simulation and found that educators who received simulation-based training demonstrated markedly higher post-training performance in multiple areas in comparison to the group that received no training. By the facts, gathered the researchers concluded in the idea that simulation technology is much more effective rather than the tradition approach of education. According to a study cited by Sanina et al., (2020), it is known that simulation-based education improves learners' logical, critical thinking, strategic, and problem-solving abilities by allowing them to integrate their understanding with real-life scenarios through computer simulation methods.

Engagement

According to Lindgren and colleagues (2016), "student engagement" pertains involvement of learners in terms of the cognitive and perceptual experience during simulation-based literacy activities. Student satisfaction, on the other hand, is closely linked to their level of satisfaction with the literacy environment (Pelletier et al., 2016). It refers to a positive emotional state that arises from students' performance as learners and promotes their participation in terms of the process of learning. Considering the two significant areas which are the engagement of students and their satisfaction, it can be interpreted that in terms of literacy effort, which is inline with the usage of computer-based simulation the expected outcomes may not be that effective without the engagement of the leraners and the feeling of satisfaction in a learning environment. Higher levels of satisfaction are associated with increased student engagement and literacy achievement.

Smart classrooms, equipped with advanced technologies, provide opportunities to enhance the active engagement of students and the pedagogical creativity of teachers without creating a sense of detachment between students and their instructors. These classrooms incorporate the use of technological tools for a conducive learning ang teaching (Alelaiwi et al., 2015).

According to Kim and Kim (2014), digital learning technologies that are interactive and cooperative make it possible for students to participate in learning and work together. These technologies include stored in the cloud management systems for learning, touch-screen whiteboards that operate electronically containing shareable resources, eBook, publishing platforms, and portable educational tools. With the development of mobile technologies, students now have access to a variety of education resources which provide helpful contents that may enables a highly personalized learning experiences (Alelaiwi et al., 2015). Implementing smart classroom technology aims to shift students' focus from traditional one-size-fits-all instruction. In the past, classrooms often had one teacher addressing a large number of students (Tinapay & Tirol, 2021).

Insufficient methods and resources that stimulate student interest have been a major challenge in classrooms. This underscores the importance of leveraging technology. Educational materials have significantly improved with the use of interactive whiteboards, PowerPoint, Voice Thread, and other tools that cater to visual and auditory learners (Tinapay et al., 2023).

Learners will have an easy access to different educational apps and can choose those that align with their interests (Aronin & Floyd, 2013). The effectiveness of utilizing technology to enhance learning can vary, in this aspect it may vary on the learners' interest and engagement (Grageda et al., 2022).

Conceptual Understanding

Fallon (2019) came to the conclusion that simulators are effective for educating students about basic physical principles and engaging learners in more complex thought processes based on the findings of an experimental research that was carried out with students from elementary schools in New Zealand. Lee et al. (2021) also noted that simulations are an effective method for cultivating students' understanding of various scientific phenomena, such as optics, moon phases, kinetics, and electromagnetism. While simulation has been used before in scientific learning, their effectiveness as a teaching tool for scientific concepts in Middle Eastern countries has not been fully explored.

According to Podolefsky et al. (2013), interactive computer simulations provide educators with a control and mastery, leading to increased appreciation and reservation of knowledge. Simulations such as these make it possible to re-create and visualize events that, when carried out in a conventional classroom or laboratory context, would be either too dangerous or too complicated to attempt (for example, geological processes), or they would take too much time.

"Learning by doing" is a method that may help make abstract ideas more tangible, according to Ramasundarm et al. (2020). Simulations can help support this kind of learning. Students have a control to do their tasks at their ideal time and it also enable them to repeat concepts that they find confusing. These type of learning fosters the development of abstract thinking and a deeper understanding. Simulations give dynamic engagement and rapid feedback to students, and 'give students a time to work of their own at their ideal time and setting. The incorporation of simulation that are computer and technology based in educational settings is becoming more commonplace. This includes the use of simulation tools that can be downloaded from the internet at no cost, such as the PhET collection that was created by the University of Colorado.

In the context of a study, the term "conceptual understanding" refers to students' abilities to recognize and find solutions to issues that do not involve performing

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mathematical calculations. Research has shown that practicing with computer simulations is an effective method for improving students' abstract understanding of drug-related topics (Faour & Ayoubi, 2018). According to Faour et al. (2018), an example is to identify the influences of simulations on the abstract knowledge of direct current (DC) circuits held by students in the 10th grade and discovered considerable increases in the students' comprehension.

Mirana (2016) conducted research to investigate how students' abstract knowledge of electricity was affected by a built lecture that included simulations on computers and a constructivist approach. Simulations based on physical education technology (PhET) as well as simulations hosted on other websites were used in the research. The results of this research implied that using computer generated simulation in the field of teaching may create and impact students when regards to improvement of students' understanding of learnings under science. Usage of interacting simulations of circuits had a favorable influence upon undergraduate learners' abstract knowledge as well as their performance in circuit-related activities, according to a research that was conducted by Hazelton and colleagues (2013). In general, the implementation of computer simulations into educational settings has shown that they have the potential to improve students' comprehension of scientific principles and to foster abilities in abstract thought (Tirol, 2021).

Impact of Computer Simulations on Scholars' Learning

Holec et al. (2004) suggest that computer simulations (CSs) have the potential to help educators visualize complex phenomena and effectively convey dynamic knowledge. They can assist in representing processes that are either too fast, too slow, or difficult to observe directly (Holec et al., 2004; Widiyatmoko, 2018). By using CSs, teachers may offer learners real-world experiences that let them build and change their knowledge, which helps them understand the ideas being studied better (Tinapay et al., 2021). Additionally, CSs allow educators to explore and imagine natural phenomena and processes that are often beyond their immediate reach (de Jong et al., 2013).

According to Widyatmoko (2018), CSs offer the advantage of allowing students to repeat the same examination multiple times. Previous study suggests how utilizing the CSs may aid learners in comprehending abstract concepts in a variety of topics. For instance, according to Faour and Ayoubi (2018), looked at how CSs affected 10th-grade students' understanding of DC circuits in a general way. The review of the data showed that students' knowledge of how DC circuits work got a lot better as the study went on.

Computer Simulations and Inquiry- Grounded literacy

In order to promote inquiry-based discourse, computer simulations should possess qualities of flexibility, dynamism, and interactivity. Perkins et al. (2013) say that this lets teachers change the values of variables and see what happens. This lets students come to their own conclusions about science ideas and principles. Nowadays, educators have access to a wide range of computer simulations, many of which are accessible over the internet. These simulations are designed to enhance education and literacy by providing visual and interactive models of various natural phenomena.

Peffer et al. (2015) and Shudayfat and Alsalhi (2023) did studies that showed how using computer models in an educational setting gives the learners new ways in grasping scientific inquiry. By allowing students to conduct experiments that may not be feasible in the physical classroom, computer simulations provide a realistic and flexible platform for scientific investigations. Banda and Nzabahimana (2021) demonstrated that the use of PhET simulations specifically enhances educators' conceptual understanding of different scientific concepts. These simulations can be integrated into various active learning environments, resembling inquiry-based instruction methods.

III. CONCLUSION

Computer simulations are widely used in the teaching of natural sciences, offering benefits for both students and educators. Research has shown that incorporating computer simulations into education improves students' overall learning outcomes, particularly in understanding challenging scientific concepts. These simulations provide interactive and engaging experiences, allowing students to explore phenomena that may not be readily observed in a traditional classroom setting. This unique learning opportunity encourages students to engage in scientific inquiry and critical thinking. While there may be challenges related to technical expertise, training, and support, the utilization of simulation that is generated in via computers has an viable impact to science education. Science education can greatly benefit from the interactive learning possibilities offered by computer simulation technologies. Simulations help depict abstract concepts and provide immediate feedback, facilitating students' absorption of new information. Virtual labs also offer a practical and accessible alternative. The way computer simulation technology is implemented and the context in which it is used can significantly impact students' learning outcomes. However, there is room for improvement in the delivery of instruction and retention of material when utilizing computer simulation technologies in science education. Further advancements and refinements are needed to optimize the educational potential of computer simulations.

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