WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Immersive Simulation in Enhancing Students' Engagement and Scientific Literacy

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ABSTRACT

The study examines the impact of immersive simulations, specifically virtual reality (VR) and augmented reality (AR), on student engagement and scientific literacy among 128 Grade 9 students at Emmanuel Christian School during the school year 2024-2025. Mean, standard deviation, and correlation were used to determine the utilization of immersive simulations, specifically virtual reality and augmented reality, in enhancing students' engagement and scientific literacy. While results showed substantial student engagement across behavioral, cognitive, and affective dimensions and improvements in scientific literacy post-exposure to immersive simulations, the correlation between immersive simulation use and scientific literacy outcomes was not significant. However, these technologies positively influenced student interest and motivation in science learning. The findings suggest that educators should integrate immersive simulations into lesson plans to enhance engagement and complement traditional teaching methods. The study highlights the need for further research on the long-term effects and effective integration of these technologies in science education.

Keywords: *immersive simulation, virtual reality, augmented reality, engagement, scientific literacy*

Introduction

The significance of incorporating science education into high school curricula cannot be overstated. It serves as a crucial foundation for students, allowing them to cultivate essential skills such as critical thinking, problem-solving, and a comprehensive comprehension of the natural world. Despite its immense importance, engaging students in science education has posed a persistent challenge. Conventional teaching approaches often struggle to capture students' interest or effectively convey intricate scientific concepts. This research endeavors to explore the potential of leveraging immersive simulations as an innovative method to enhance high school students' engagement and scientific literacy.

In the ever-evolving landscape of science education, the integration of immersive simulation-based learning has emerged as a transformative approach that has the potential to revolutionize the way students engage with scientific concepts and phenomena. Immersive simulation-based education provides learners with the opportunity to bridge the gap between theoretical knowledge and practical application by immersing them in virtual environments that closely resemble real-world scenarios.

Immersive simulations encompass a range of dynamic and captivating virtual environments that provide users with the opportunity to engage with and manipulate various scenarios in real-time. These simulations have proven particularly effective in educational settings, where they serve as powerful tools for illustrating and exploring complex subjects in a controlled and interactive fashion, especially within the realm of scientific education.

Considering the varying learning styles of students is essential, according to one of the distinguished experts in this study, when investigating how immersive simulations might improve student engagement, scientific literacy, and confidence in the context of scientific instruction (Almasri, 2022). The results of the research, which are highly significant, show that using immersive simulations directly improves student engagement, scientific literacy, and self-assurance, which in turn increases students' happiness and satisfaction with the learning process. In addition, the research strongly suggests that immersive simulations be incorporated into the curriculum to maximize student performance. It also strongly supports the use of immersive simulations as an extremely successful teaching strategy in the field of scientific education.

One of the key advantages of immersive simulation-based learning is its potential to enable students to manipulate concepts, principles, systems, and variables in a safe and controlled environment, which can foster a deeper understanding of scientific principles. This approach not only enhances the learning experience but also allows for the exploration of scenarios that may be too dangerous, costly, or time-consuming to replicate in the physical world. By highlighting this aspect, the audience can feel reassured about the safety and control provided by immersive simulations in science education.

The primary aim of this research is to thoroughly analyze the positive impact of utilizing different immersive simulations on students' engagement, scientific literacy, specifically their comprehension and application in science. The study will delve deeply into the ways in which these immersive simulations positively influence different dimensions of student engagement, including behavioral, emotional, cognitive aspects, and their scientific literacy. Additionally, it aims to highlight the potential of immersive simulations not only in filling gaps in scientific comprehension and application but also in fostering a more constructive and optimistic attitude toward the subject among students.

Through the exploration of technology-enhanced learning tools in the context of science education, this study seeks to make a significant contribution to the ongoing discourse surrounding innovative pedagogical strategies. The primary aim is to enhance the appeal and accessibility of science to students across different learning styles and backgrounds. As a result, the study endeavors to generate valuable insights that can be leveraged by educators, curriculum developers, and policymakers. These insights are expected to facilitate the elevation of the standard of science education. By emphasizing not only the acquisition of scientific knowledge but also the cultivation of a fervent enthusiasm for its study and practical application, the study aspires to nurture a cohort of students who are not only proficient in science but also passionate about its practical application.

2. Literature Review

2.1 On Immersive Simulation

In a recent research study, it was revealed that the integration of a simulation-based 7E context-driven instructional strategy led to a substantial increase in student engagement in secondary school chemistry as compared to traditional teaching methods. These findings underscore the potential for enhanced chemistry learning and heightened student involvement through the adoption of this innovative strategy. (Demelash, Andargie, & Belachew, 2024).

Incorporating immersive simulations into the science curriculum can provide students with invaluable opportunities for hands-on learning experiences, fostering exploration and inquiry. According to Makransky, Petersen, and Klingenberg (2020) Immersive Virtual Reality (IVR) is widely acclaimed for its potential to offer captivating and interactive learning experiences that not only capture the interest of learners but also enhance their self-efficacy. By creating simulated environments that users can explore and interact with, IVR has the ability to deeply engage learners and boost their confidence in their abilities. This technology has the capacity to revolutionize the field of education by providing dynamic and personalized learning opportunities that cater to individual learning styles and preferences.

According to Tscholl and Lindgren (2016), immersive simulations are acknowledged as extremely useful instruments in science education because they offer children captivating and interactive experiences. This strategy is distinct from conventional methods in that it generates a lively setting where children can personally investigate scientific principles.

The study aimed to examine the influence of online collaboration tools on science education outcomes for middle school students. It found that the use of digital collaboration platforms led to significantly higher post-test scores, demonstrating a positive impact on learning achievement, engagement, and motivation. These results emphasize the potential of online collaboration tools to enhance science education and highlight the need for further research to explore their effectiveness across diverse educational settings. The findings carry important implications for educators, educational institutions, policymakers, and curriculum developers (Ateş & Köroğlu, 2024).

Using simulations in science education can help students understand complex concepts, but a lack of support can lead to misconceptions. A study with seventh-grade students in China used a self-explanation strategy to improve comprehension of physics concepts. The experimental group showed better learning outcomes and more inquiry behaviors than the control group (Li, Su, & Ouyang, 2023).

2.2 On Virtual Reality

According to Tsivitanidou, Georgiou, and Ioannou (2021), their research indicates that incorporating immersive VR technology into inquiry-based teaching can improve learning results, particularly for students with a positive outlook. It emphasizes the potential of VR as a powerful educational resource to increase engagement and comprehension in physics. In summary, the results provide important insights into customizing immersive experiences to accommodate various student attitudes, promoting a more effective science learning environment.

According to Liu, Wang, Lei, Wang, and Ren (2020), students taught using IVR showed significantly higher academic performance than those in traditional classrooms. It suggests that immersive experiences can improve comprehension and retention of scientific concepts, as well as increase students' engagement, curiosity, and motivation to learn science. The results highlight the potential of IVR in education to enhance student engagement, academic achievement, and positive attitudes toward learning science.

According to Cheng and Tsai (2020), using IVR can make students more interested in and enthusiastic about science, which can lead to a better attitude. This change in attitude could help more students stay interested in science and consider studying or working in science-related fields. The study also found that using IVR helps students learn better. When students interact in immersive environments, they are more likely to use different thinking and reflecting strategies, which helps them understand and remember scientific ideas. This shows that IVR can help students learn to manage their own learning in science subjects.

This paper introduces two gamified virtual labs for teaching and explores their effectiveness in enhancing student engagement and promoting active learning. The study found that gamified virtual labs can be valuable tools for low-risk interactive learning. However, more research is needed to compare them with simple virtual simulations. Overall, integrating gamified virtual labs into higher education curricula can improve the educational delivery process and offer practical benefits (Sanzana, Abdulrazic, Wong, Karunagharan, & Chia, 2023).

This study explores how immersive virtual reality (VR) might improve science education by giving students access to interactive, three-dimensional (3D) settings where they can study complex science concepts. Interestingly, the results show that using VR significantly increases students' engagement and comprehension of scientific ideas. Furthermore, the study emphasizes how crucial it is to create well considered virtual reality experiences that align with learning goals. In order to meet the varied demands of different learning preferences, it also promotes the incorporation of VR technology into scientific courses as a way to improve engagement and learning results (Matovu et al., 2022).

2.3 On Augmented Reality

This study looks at how immersive augmented reality (AR) technology affects high school students' cognitive load, learning motivation, and understanding of environmental concerns. The results imply that augmented reality (AR) can improve students' intrinsic motivation and environmental literacy, but it might also result in an increase in cognitive load. In order to enhance learning results, the study suggests integrating augmented reality (AR) into environmental education, with an emphasis on maximizing advantages while balancing cognitive load (Shakirova et al., 2023).

Augmented reality has demonstrated its effectiveness in improving students' academic performance, contentment, and enthusiasm for science education. With its ability to convert conventional learning settings into lively and interactive environments, AR technology has the potential to significantly enhance the overall educational experience. Ongoing research will be crucial in refining AR applications and comprehending their enduring effects on student achievements as the field continues to progress (Abdullah, Baskaran, Mustafa, Ali, & Zaini, 2022).

According to the study of Arici, Yilmaz, and Yilmaz (2021), using augmented reality (AR) in science education has been shown to increase student and teacher engagement and motivation. However, incorporating AR into the classroom requires adequate resources, training, and support for both educators and students. Teachers face obstacles such as limited training and high costs, while students may need help using AR technology effectively.

According to the study of López-Belmonte, Moreno-Guerrero, López-Núñez, and Hinojo-Lucena (2020), AR technologies elevate student engagement by converting passive learning into interactive experiences. Through real-time visualization and manipulation of three-dimensional models like anatomical structures and historical artifacts, students can enhance their understanding and retention of knowledge. These immersive experiences also cultivate critical thinking and problem-solving abilities.

According to the study of Salar, Arici, Caliklar, and Yilmaz (2020), it has been discovered that AR positively influences student engagement and learning experiences, with students expressing heightened motivation and increased involvement when using AR compared to traditional educational methods. However, there are also concerns about information retention, as the immersive nature of some AR experiences may detract from the core content and potentially impact overall learning outcomes.

2.4 On Learning Engagement

The development of skills and sustained interest in science is crucial in junior high education. A recent study shows that students engage more with science when in a supportive learning environment. It found a strong link between academic engagement and the quality of this environment, highlighting factors like students' enjoyment in science activities. The findings emphasize the need for a positive and enjoyable science learning atmosphere, hands-on education, and efforts to meet students' specific needs. This research can help enhance our understanding of scientific education and improve teaching methods. (Mohamad, 2024)

Gamification has been used to enhance learner engagement through intangible rewards like virtual points and badges. Some learners want to exchange these for tangible benefits. While tangible rewards are common in commercial gamification, their effectiveness in education is not well-studied. A recent randomized controlled trial found that students who received tangible rewards outperformed those who received intangible rewards in terms of motivation, engagement, and learning performance. This has practical implications for educators using gamification in their classes (Xiao & Hew, 2023).

The study aimed to explore the influence of online learning environments on learners' empowerment, learning behavioral engagement, and learning motivation. Results showed that online learning environments significantly and positively influenced learners' empowerment, learning behavioral engagement, and learning motivation. Furthermore, learning motivation mediated the relationship between online learning environments and learning behavioral engagement. The study highlighted the importance of constructing appropriate online learning environments in accelerating students' learning behavioral engagement (Pan, 2023).

The concept of student engagement is multifaceted, encompassing various components such as attention, curiosity, interest, optimism, and passion that students demonstrate during the process of learning or being taught. This involvement extends beyond just behavioral aspects and includes emotional and cognitive engagement, which reflects students' feelings and thoughts about their learning experiences (Bond et al., 2020).

The study aimed to explore how motivation, learning self-efficacy, and self-monitoring affect learning engagement in online environments. 354 higher education students from Taiwan participated. The results indicated that motivation positively influenced learning self-efficacy, self-monitoring, and learning engagement. Motivation had a direct influence on learning engagement and an indirect influence through learning self-efficacy and self-monitoring. Learning self-efficacy also directly impacted self-monitoring and learning engagement. The study found that learning self-efficacy and self-monitoring partially mediated the influence of motivation on learning engagement in online environments (Alemayehu & Chen, 2021).

2.5 On Scientific Literacy

The study conducted in Tanzania delved into how science teachers' classroom practices shape students' scientific literacy (SL). It identified five key instructional practices: guided reading, code-switching, educational print and visual aids, science experiments, and science projects. However, these practices were predominantly print-based and teacher-led, thereby constraining active scientific thinking and literacy learning. The findings present a compelling case for improving teacher education and professional development programs (Iddy, Fussy, Mkimbili, & Amani, 2024).

According to the study of Adnan, Mulbar, Sugiarti, and Bahri (2021), they acknowledge a significant issue pertaining to inadequate scientific literacy among students, highlighting the challenges many students face in comprehending and applying scientific principles in their biology classes. Teaching approaches are crucial for cultivating students' scientific literacy. Employing inquiry-based teaching and making use of diverse educational materials can help educators establish a more engaging learning atmosphere that promotes student engagement and cultivates a better grasp of biological ideas. These enhancements are vital not just for boosting scientific literacy but also for equipping students to effectively navigate a world centered on science.

2.6 On Lesson Planning in Science

According to Iqbal, Siddiqie, and Mazid (2021), the need for evolving lesson planning in education to better serve diverse learners and enhance teaching effectiveness. It emphasizes that effective lesson plans should promote student engagement and active learning rather than just outlining content delivery. The research critiques static planning models and advocates for a dynamic approach that considers students' motivations, backgrounds, and learning styles, incorporating constructivist principles like collaborative and experiential learning. Additionally, it highlights the importance of ongoing professional development for teachers, encouraging them to revise lesson plans based on reflection and student feedback. The study concludes that rethinking lesson planning is crucial for improving teaching and learning outcomes, urging educators and policymakers to invest in adaptive strategies and innovative, student-centered methodologies.

According to Sherab, Rai, and Hopwood (2024), the questioning methods used by teachers play a crucial role in creating interactive lectures that keep students interested and engaged during science lessons.

According to the study of Kerans and Ngongo (2021), combining problem-based learning with lesson study significantly boosts collaboration among teachers and enhances students' scientific abilities. Lesson studies are effective for professional development, allowing educators to exchange insights and develop improved lesson plans, which leads to more effective teaching techniques. When students engage with real-world challenges, they become more interested and driven, resulting in a deeper grasp of scientific principles. The findings emphasize the necessity for science teachers to embrace innovative teaching methods to create dynamic classroom environments that encourage critical thinking. Ultimately, the study promotes the widespread adoption of this integrated approach to enhance science education and calls for continued support and training for teachers.

According to, Großmann and Krüger (2023), their study evaluates a new rubric, the Rubric for Assessing Lesson Plans (RALP), designed to assess science lesson plans. It addresses the need for reliable tools to enhance lesson planning, essential for effective teaching. Key findings show that RALP systematically evaluates critical components such as learning objectives and instructional strategies. It was tested on preservice and trainee teachers' plans, revealing significant quality differences based on their experience. The research emphasizes integrating RALP into teacher education programs to support professional development and improve lesson planning. Overall, the study highlights the importance of structured lesson plans and effective assessment tools in science education.

According to the study of Zaragoza, Seidel, and Santagata (2023), They explore a structured framework designed to assist preservice teachers in crafting effective lesson plans. The main findings suggest that this framework enhances their understanding of crucial teaching elements—such as learning objectives and assessment strategies—by breaking them down in a systematic manner. It fosters critical reflection, which in turn boosts clarity and confidence in making instructional choices. Furthermore, the framework encourages collaborative dialogues among preservice teachers, promoting peer feedback and a supportive community in their professional growth. Overall, the study emphasizes the significance of scaffolding in teacher preparation and advocates for the use of integrated tools within education programs to improve lesson planning and classroom effectiveness.

Methodology

Research Design

The study employed a developmental design. The intention is to evaluate teaching methods and educational accomplishments, providing valuable insight into how diverse teaching strategies impact students' progress at different stages of their academic journey. This understanding has the potential to shape future educational approaches and policies. It assessed the effects of immersive simulations on student engagement and scientific literacy. It is an essential method for comprehending the changes that occur throughout various stages of development. The study utilized quantitative research methods to evaluate the effectiveness of the intervention thoroughly.

Participants of the Study

The study involved 128 grade 9 students of Emmanuel Christian School, SY 2024-2025. There are 81 male students and 43 female students. The respondents came from the Main Branch of Emmanuel Christian School in San Lorenzo IE, City of Santa Rosa where they will be actively engaging with immersive simulations as part of their curriculum. The research employed a purposive sampling method to select Grade 9 students based on specific criteria, including age, academic performance, prior technological experience, consistency in participation, and adherence to ethical standards for voluntary participation. The students are in a heterozygous class. The goal is to assess the impact of immersive simulation on their behavioral, affective, and cognitive engagement, as well as their scientific literacy, specifically in terms of how they comprehend and apply scientific principles in their daily activities.

Instrumentation and Data Gathering Process.

The study employed various instruments to collect the data necessary to answer the research questions. These include student experiences survey (Likert scale) on using immersive simulations such as virtual reality and augmented reality; a student engagement survey (Likert scale) that includes different aspects such as behavioral, affective, and cognitive; science assessments (pretest and posttest) to assess their scientific literacy specifically their comprehension and how they can apply it in their daily activities; and a learning plan which was integrated by the use of immersive simulation (virtual reality and augmented reality). Gizmo served as a virtual reality laboratory and Earth Viewer in augmented reality. The assessments were conducted in the science computer laboratory.

Data Analysis.

Descriptive statistics were used to summarize data from students, employing measures of central tendency, like the mean, to assess engagement and scientific literacy scores, alongside measures of dispersion, such as standard deviation, to understand variability. Inferential statistics, including paired sample t-tests, were used to evaluate the effectiveness of immersive simulations by comparing pre- and post-assessment scores of scientific literacy. Correlation analyses examined the relationships between virtual reality and augmented reality and their impact on behavioral, affective, and cognitive engagement, as well as on understanding and applying scientific concepts.

Research Ethics.

The internal panels and the school's principal gave their approval to conduct the study after the pilot testing. The parents received a letter informing them that their children participated in a study involving the use of various gadgets, applications, and pre-assessments and post-assessments. Ensuring them the safety of their children while conducting the study.

Findings and Discussion

Table 1

Students' experience with immersive simulation as virtual reality

Indicators	Mean	SD	VI
1. captivates the feeling of being transported into the virtual environment.	2.72	0.739	SlE
2. engages to focus during the entire learning experience.	2.91	0.699	SuE
3. helps to understand difficult ideas and learn the lessons easily.	2.98	0.698	SuE
4. fills me with excitement and curiosity, making the learning experience enjoyable and engaging.	3.24	0.800	SuE
5. permits active participation in the learning experience instead of just observing and listening.	3.02	0.855	SuE
Overall	**2.97**	**0.506**	**SuE**

Legend: 1.0-1.49 (Not experienced-NE); 1.50-2.49 (Slightly experienced-SlE); 2.50-3.49 (Substantially experienced-SuE); 3.50-4.0 (Highly experienced-HE).

Table 1 indicates that students substantially experienced immersive simulations through virtual reality to a significant extent. This suggests that although students typically engage with and gain knowledge from the virtual experience, their immersion and interaction levels do not reach the highest possible category. Since the students used this twice a month or depending on their schedule, the students cannot fully immerse themselves in this technology. The indicator that was rated the highest was when the students were filled with excitement and curiosity, and when they were permitted to participate actively, demonstrating that students find VR learning enjoyable and captivating. The students enjoyed the activities and the graphic representations of the science topics in the virtual laboratory. They are encouraged to participate actively, rather than passively, when they are reading about it in a book. This suggests that VR enhances student engagement and immersion. In contrast, the lowest-scored indicator is the feeling of being transported into the virtual environment, which falls into the 'slightly experienced' category. This implies that while VR is engaging, it may not consistently provide a fully immersive or realistic experience for all students. Overall, students report a positive experience with immersive VR simulations, particularly in terms of engagement, participation, and understanding. However, the full immersion in the virtual world is not as strong, suggesting potential areas for improvement, such as enhancing the realism of the VR setting or addressing any technical issues that may impact the sense of presence.

Table 2

Students' experience with immersive simulation as augmented reality

Indicators	Mean	SD	VI
1. feels realistic and effectively conveys the lesson easily.	3.03	0.764	SuE
2. actively engages in attentiveness during the learning experience.	3.04	0.780	SuE
3. improves comprehension of the main concepts being taught.	3.08	0.705	SuE
4. motivates enjoyment and engagement in the learning experience.	3.12	0.812	SuE
5. engages interaction with the lesson instead of just passively doing it.	2.94	0.768	SuE
Overall	3.04	0.529	SuE

Legend: 1.0-1.49 (Not experienced-NE); 1.50-2.49 (Slightly experienced-SlE); 2.50-3.49 (Substantially experienced-SuE); 3.50-4.0 (Highly experienced-HE).

Table 2 indicates that students substantially experienced augmented reality (AR) in their learning. This suggests that AR is generally effective in enhancing engagement, comprehension, and interaction, though it does not reach the highly experienced category.

The indicator that received the highest rating is "motivates enjoyment and engagement in the learning experience," indicating that AR creates an engaging and enjoyable learning environment. It demonstrated the important role augmented reality (AR) plays in creating a fun and interesting learning environment. AR increases students' engagement in the learning process and piques their interest by including immersive experiences and interactive components. Improvement in concept comprehension and attentiveness are also strong points, indicating AR's effectiveness in maintaining focus and aiding understanding. Meanwhile, "engages interaction" is the indicator that has the lowest score, suggesting that while AR encourages participation, there may still be areas for improvement in fostering deeper interaction.

Learners perceive augmented reality (AR) as a valuable tool for transforming traditional lessons into engaging, comprehensible, and immersive educational experiences. The findings of the study indicate that AR significantly boosts students' focus and motivation, resulting in a positive influence on the overall educational process. This heightened engagement is attributed to the interactive nature of AR, which stimulates curiosity and encourages exploration.

However, it is worth noting that the evaluation also revealed a somewhat lower score in the area of interactive engagement. This suggests that while AR is effective in enhancing the learning experience, there is still room for improvement. By refining AR-related activities and incorporating more opportunities for active participation, educators can further elevate the quality of active learning experiences, ensuring that students not only absorb information but also actively engage with it in meaningful ways.

Table 3

Students' level of engagement in using immersive simulations as to behavioral engagement

Indicators As a student I. . .	Mean	SD	VI
1. take part in classroom activities related to science, such as performing experiments and participating in class discussions.	3.24	0.769	SuE
2. make sure to complete my science assignments and homework on time.	3.26	0.785	SuE
3. participate in group projects and work collaboratively with my classmates.	3.54	0.691	HE
4. cooperate with my groupmates during group work.	3.61	0.671	HE
5. use different resources, such as books and educational applications, to help me understand science lessons easily.	3.15	0.843	SuE
Overall	**3.36**	**0.520**	**SuE**

Legend: 1.0-1.49 (Not engaged-NE); 1.50-2.49 (Slightly engaged-SlE); 2.50-3.49 (Substantially engaged-SuE); 3.50-4.0 (Highly engaged-HE).

Table 3 indicates that students are substantially engaged in behavioral aspects of learning science. This suggests that students actively participate in class activities, complete assignments, and use learning resources, though their engagement level does not consistently reach the highest category.

The highest-scoring indicators are cooperation with my groupmates and participation and collaboration both falling into the highly engaged category. This result shows that when cooperation and group effort are emphasized in collaborative learning settings, students do well. In group activities, it emphasizes their tendency to actively interact with peers, showing a readiness to exchange ideas, encourage one another, and make a significant contribution to common goals. It goes without saying that creating a collaborative atmosphere may improve students' overall educational experiences and raise their academic achievement. Other indicators, like participating in science experiments and class discussions, as well as completing assignments on time and using extra resources, are rated slightly lower but still show substantial engagement. This suggests students are more engaged in group activities than in individual tasks.

Students exhibit robust behavioral engagement, especially during collaborative learning settings, highlighting the benefits of group-based tasks in enhancing their active participation. These group activities encourage interaction, communication, and a shared sense of purpose, which together significantly boost motivation and involvement. However, this enthusiastic engagement does not translate as effectively to independent learning tasks. Activities such as utilizing educational materials, conducting individual research, and completing assignments tend to see lower levels of participation and enthusiasm.

To address this gap, it is essential to promote self-directed learning strategies that empower students to take ownership of their educational journeys. By developing skills in time management, goal setting, and self-assessment, students can enhance their ability to engage with independent tasks. Additionally, emphasizing the importance of personal responsibility in their learning processes can foster a greater sense of accountability. Educators can play a crucial role in this transformation by providing guidance, resources, and support that encourage students to embrace independent study as a valuable complement to their collaborative experiences. This dual approach could significantly improve overall engagement and learning outcomes across various tasks.

Table 4

Students' level of engagement in using immersive simulations as to affective engagement

Indicators As a student I. . .	Mean	SD	VI
1. am captivated and fascinated by the lessons discussed in my science classes.	2.90	0.715	SuE
2. feel connected to the lessons presented in class, and I find them relevant to my life.	2.60	0.775	SuE
3. find the classroom environment to be supportive and encouraging, which improves my engagement with the subject.	2.97	0.836	SuE
4. share my ideas and views during science classes.	2.12	0.870	SlE
5. share what I learn with others.	2.50	0.984	SuE
Overall	**2.62**	**0.542**	**SuE**

Legend: 1.0-1.49 (Not engaged-NE); 1.50-2.49 (Slightly engaged-SlE); 2.50-3.49 (Substantially engaged-SuE); 3.50-4.0 (Highly engaged-HE).

Table 4 indicates that students are substantially engaged in the affective aspects of learning science. This indicates that students actively engaged generally find science lessons interesting and relevant, but their emotional connection and willingness to express ideas could be improved.

Students' assessment of the classroom atmosphere as encouraging and their participation in science classes were the indicators with the highest rate. This suggests that students feel supported and appreciated in their educational environment, revealing the need for a supportive and nurturing learning environment. Their excitement for science classes also shows that the material is interesting and relevant and that it is presented in a way that piques their interest. All of these elements work together to create a more engaging educational experience that encourages curiosity and a love of learning. Feeling that science lessons are relevant to their lives and sharing what they learn with others are also rated as substantially engaged, indicating that students see some personal importance in their learning. Among the several engagement indicators, the indication that shows how open students are to exchanging ideas during scientific sessions now has the lowest rating, falling into the slightly engaged range. Despite a general interest in science, students appear hesitant to actively share their own ideas, according to this result. A lack of confidence in their contributions, a fear of peer criticism, or a general lack of experience in collaborative learning environments are some of the possible causes of this hesitancy. Therefore, it is essential to create a more inclusive environment that fosters students' ability to express their opinions and engage meaningfully in scientific discussions, even in the face of enthusiasm for science.

In science learning, students generally demonstrate a reasonable amount of emotional involvement, particularly in terms of their interest in the subject and the encouragement they receive from peers. However, a significant number of them may hesitate to express their thoughts or opinions during class discussions. This indicates the necessity for us to prioritize the creation of inclusive environments and to bolster their confidence in contributing. By fostering open dialogues and providing organized chances for every student to voice their ideas, we can improve their engagement and strengthen their connection to the learning experience.

Table 5

Students' level of engagement in using immersive simulations as to cognitive engagement

Indicators As a student I. . .	Mean	SD	VI
1. think carefully and analyze the lesson so I can understand it better.	3.26	0.685	SuE
2. notice the connection between different lessons in science and I can bring them together to form clearer and better comprehension.	2.81	0.813	SuE
3. aim to gain a thorough understanding of science lessons rather than simply memorizing information.	2.97	0.919	SuE
4. make an effort to learn more scientific subjects outside of what we learn in class, actively looking for extra materials to help me better understand the topics.	2.81	0.934	SuE
5. reflect on the knowledge I gained in my science class and examine its relevance to my personal experiences and understanding.	2.69	0.859	SuE
6. involve in solving problems during lessons and constantly seek different approaches to address scientific questions.	2.60	0.864	SuE
7. can apply the knowledge and skills learned in science classes to real-life situations or to different subjects.	2.71	0.853	SuE
8. frequently explore questions that arise during science lessons because I am curious about the subject matter.	2.58	0.875	SuE
9. am ready to take on complex scientific ideas and concepts, even if they are challenging to understand.	2.69	0.903	SuE
10. set specific goals for what I want to learn in my science studies and keep track of how well I'm doing in reaching those goals.	2.94	0.814	SuE
Overall	**2.80**	**0.509**	**SuE**

Legend: 1.0-1.49 (Not engaged-NE); 1.50-2.49 (Slightly engaged-SlE); 2.50-3.49 (Substantially engaged-SuE); 3.50-4.0 (Highly engaged-HE).

Table 5 The data indicates that students are substantially engaged in cognitive aspects of learning science. This indicates that students actively participate and contribute but their level of enthusiasm might be slightly pronounced in comparison if they were highly engaged. This suggests that students put effort into understanding and applying scientific concepts but may have varying levels of deep engagement across different cognitive processes.

The indicator that has the highest score is analysis and thinking carefully. It shows that the students showed an increased degree of engagement in promoting a better comprehension of difficult ideas, which made problem-solving and decision-making more efficient. Using analytical techniques, students demonstrated an enhanced ability to evaluate claims and integrate new ideas, thereby improving their overall educational experience. In addition, students' dedication to attaining meaningful learning experiences, rather than relying solely on rote memory, is demonstrated by their active attention to setting and reaching goals and the aim of understanding science lessons. This emphasis on goal-setting demonstrates that students are active learners who strive to comprehend the fundamental ideas and applications of scientific concepts, rather than merely being passive recipients of knowledge. Students are developing critical thinking abilities and a greater understanding of the scientific method by placing a strong emphasis on understanding and personal development in their coursework. This method emphasizes how crucial it is to create a learning environment that values inquiry and deep involvement with the subject matter. Other indicators such as, noticing connections between science lessons that enhance understanding and making an effort to explore scientific topics beyond class and seek extra materials for better understanding are rated slightly lower but still reflect a solid effort in expanding knowledge. Meanwhile, the indicators which have the lowest scores are often asking questions during science lessons because of curiosity about the topic and involvement in solving problems during lessons and constantly seek different approaches to address scientific questions. These results point to a trend: while students show some interest in the science subject, it's possible that they lack the innate drive to learn more about subjects outside of scheduled class discussions. This unwillingness to independently seek solutions to challenging scientific issues represents a missed opportunity to enhance critical thinking and inquiry skills. However, in order to improve their curiosity, problem-solving abilities, and in-depth investigation of scientific concepts, students might need more instructional help. Enhancing activities that encourage self-directed research and inquiry-based learning might assist optimize the cognitive advantages of immersive simulations.

Students exhibit critical thinking abilities, establish clear objectives, and demonstrate a solid grasp of the material. However, they may benefit from additional motivation to explore ideas independently and tackle problems on their own. This indicates that they would likely excel with activities that stimulate curiosity and offer practical learning experiences. To enhance their engagement in science, we could create more opportunities for open-ended inquiries, encourage them to pursue investigative projects and assist them in connecting scientific concepts to other subjects. This strategy could significantly ignite their interest and enrich their understanding.

Table 6

Pre- and post- scientific literacy assessment of the Grade 9 students as to their comprehension and application of scientific principles

Scientific Principles	PRE-TEST			POST-TEST		
	Mean	SD	VI	Mean	SD	VI
Comprehension	13.44	1.422	Proficient	15.24	1.085	Advanced
Application	13.85	1.389	Proficient	16.00	0.846	Advanced

Legend: 5 and below (Beginning); 6-8 (Developing); 9-11 (Approaching Proficiency); 12-14 (Proficient); 15-17 (Advanced).

Table 6 indicates an improvement in scientific literacy among Grade 9 students in both comprehension and application of scientific principles after immersing in immersive simulation.

The students initially received a proficient rating on the comprehension pre-test, demonstrating a solid understanding of scientific concepts. Their performance improved to an advanced level on the post-test after engaging with an immersive simulation, where they analyzed climatic phenomena and their impacts on the environment and human activities. This progress indicates not only their enhanced understanding but also their ability to apply these ideas in various contexts. The reduced standard deviation in post-test scores signifies greater consistency in student mastery and self-confidence with the material.

Overall, the transition from competency to advanced comprehension showcases the effectiveness of the teaching strategies and the students' dedication. The findings suggest that the educational approach significantly improved students' scientific literacy, as evidenced by higher mean scores and decreased variability. Future initiatives could focus on sustaining this progress through more inquiry-based learning and practical applications.

Table 7

Significant Correlation of immersive simulations and engagement

Immersive Simulation	Students' Engagement		
	Behavioral	Affective	Cognitive
Virtual Reality	0.391**	0.285**	0.408**
Augmented Reality	0.309**	0.266**	0.405**

***Correlation is significant at the 0.01 level (2-tailed). +1.0 Perfect positive +/- association +0.8 to +1.0 Very strong +/- association +0.6 to +0.8 Strong +/- association +0.4 to +0.6 Moderate +/- association +0.2 to +0.4 Weak +/- association 0.0 to +0.2 Very weak +/- or no association*

Table 7 highlights the significant relationship between immersive simulations in virtual reality (VR) and augmented reality (AR) and students' behavioral, affective, and cognitive engagement. Students using VR and AR tend to engage more in critical thinking, problem-solving, and understanding scientific concepts. Behavioral engagement shows a weak positive correlation, slightly stronger for VR, indicating it encourages participation and collaboration but is influenced by other factors like teaching methods and classroom environment. Affective engagement has the weakest correlation, suggesting immersive simulations have limited impact on students' emotional connection to learning despite possible enjoyment. Cognitive engagement shows the strongest correlation, though still weak to moderate, indicating some effectiveness in stimulating cognitive involvement. Overall, while immersive simulations positively influence student engagement, especially cognitively and behaviorally, they work best when combined with interactive teaching strategies and reflection exercises.

Table 8

Significant Correlation of immersive simulations and scientific literacy

Immersive Simulation	Scientific Literacy	
	Comprehension	Application
Virtual Reality	0.109	-0.041
Augmented Reality	0.161	0.061

***Correlation is significant at the 0.01 level (2-tailed). +1.0 Perfect positive +/- association +0.8 to +1.0 Very strong +/- association +0.6 to +0.8 Strong +/- association +0.4 to +0.6 Moderate +/- association +0.2 to +0.4 Weak +/- association 0.0 to +0.2 Very weak +/- or no association*

Table 8 shows that there is no significant relationship between immersive simulation as to virtual reality and augmented reality and scientific literacy as to comprehension and application. The findings suggest that neither virtual nor augmented reality demonstrates a meaningful correlation with students' scientific literacy, particularly in terms of comprehension and application. The effects are insignificant, even though augmented reality (AR) has a somewhat greater connection than virtual reality (VR). These findings highlight the need for further research to determine the true educational benefits of immersive technology in scientific education, possibly using larger samples, experimental methods, or qualitative insights.

Table 9

Significant Difference on Pre- and post-scientific literacy assessment of the student as exposed to immersive simulation as to scientific literacy

Paired Samples T-Test

Pretest-Posttest						95% Confidence Interval	
	statistic	df	p	Mean difference	SE difference	Lower	Upper
Comprehension	-22.2	123	< .001	-1.80	0.0810	-1.96	-1.64
Application	-20.0	123	< .001	-2.15	0.1072	-2.36	-1.93

Note. H_a $\mu_{\text{Measure 1 - Measure 2}} \neq 0$

Table 9 presents paired samples t-test results, revealing a significant improvement in students' scientific literacy in both comprehension and application following immersive simulations. The t-statistic and p-value indicate a notable difference between pretest and posttest scores, underscoring the simulations' effectiveness in enhancing students' understanding and ability to apply scientific concepts.

The findings show that students not only grasp foundational concepts but also develop essential skills for real-world application. This dual improvement enriches the educational experience and prepares students for future academic and professional challenges.

Overall, immersive simulations provide engaging learning environments that deepen comprehension and foster problem-solving skills, enabling students to confidently tackle complex scientific issues and make informed decisions. Incorporating these simulations into education can significantly enhance students' readiness to face real-world challenges.

Conclusion

These are the following conclusions of the study:

1. Since there is a significant relationship between immersive simulations and students' learning engagement, however, there is no significant relationship between immersive simulation and scientific literacy. Therefore, the null hypothesis is partially supported.

2. As indicated in the findings, there is a significant difference in pre- and post-scientific literacy assessment after exposure to immersive simulation. Therefore, the null hypothesis is not supported.

Based on the conclusions above, the following are the recommendations of the study:

1. The teacher may consider encouraging self-expression and participatory conversations in science classrooms to increase the students' affective engagement. By creating a space where learners feel safe to voice their ideas, ask questions, and share personal experiences related to scientific concepts, educators can deepen the connection between students and the material. Utilizing interactive discussions, collaborative projects, and hands-on activities can stimulate curiosity and motivate students to actively contribute, thus enriching their overall learning experience and fostering a passion for science.

2. Develop targeted teaching methods to bridge the gap between scientific literacy and immersive simulation. These strategies should consider diverse learning styles and incorporate hands-on experiences, ensuring students not only understand scientific concepts but also apply them in realistic scenarios. By integrating interactive simulations into the curriculum, educators can promote critical thinking and problem-solving skills, helping students to visualize complex scientific processes and enhance their engagement with the material.

3. Employ a mixed-methods approach that integrates inquiry-based and conventional learning methodologies with immersive simulations. This involves creating tailored instructional strategies that not only focus on fundamental scientific concepts but also integrate hands-on, immersive simulations that engage students in real-world applications of science.

4. Next researchers can investigate further how different immersive simulations other than virtual reality and augmented reality can impact students' long-term learning outcomes. Extended exposure to these applications may also prove beneficial.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was not supported by any funding.

Institutional Review Board Statement

This study was conducted in accordance with the ethical guidelines set by Emmanuel Christian School. The conduct of this study has been approved and given relative clearance(s) by Emmanuel Christian School and Laguna State Polytechnic University – San Pablo City Campus.

Declaration

The author declares the use of Artificial Intelligence (AI) in writing this paper. In particular, the author used Quillbot and Grammarly in summarizing and paraphrasing ideas.

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