Simulation and Augmented Reality on Academic Performance and Engagement in Grade 11 Earth and Life Science

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Abstract: As emerging technologies continue to reshape classroom instruction, this quasi-experimental study explored the effects of simulation and augmented reality on the academic performance and engagement of grade 11 learners in earth and life science. It was conducted at salawagan national high school, school year 2024-2025. The study used a set of developed and validated science lessons, a validated research-made 60-item academic performance test, and a validated adapted learners' engagement questionnaire. The means and standard deviations of the data gathered were computed. Ancova and a one-way independent t-test were employed at the 0.05 level of significance. The findings revealed that the academic performance of earth and life science learners taught using simulation and augmented reality was interpreted as not meeting expectations. Furthermore, there was no significant difference in the academic performance of grade 11 learners in simulation and augmented reality. The study showed that learners exposed to simulation and augmented reality have shown high engagement in earth and life science. Also, there was no significant difference in the learners' engagement between the groups exposed to simulation and augmented reality.

Keywords**:** *Simulation, Augmented Reality, Academic Performance, Engagement, Earth and Life Science, Multimedia Instruction.*

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I. INTRODUCTION

Modern educational tools like Simulation and Augmented Reality are changing how science is taught and learned. These technologies help bring abstract and complex topics to life, making them easier for learners to understand and engage with. Instead of just reading or looking at diagrams, learners can now explore scientific concepts in interactive and visual ways, especially useful in Earth and Life Science, where many ideas are spatial, dynamic, or hard to visualize.

Simulations let learners run virtual experiments, adjust variables, and see real-time outcomes, encouraging curiosity and critical thinking. Augmented Reality overlays 3D models like cells, ecosystems, or geological formations into the real world, making lessons feel more connected and meaningful. When used purposefully, these tools don't just make science more interesting; they help learners understand better and remember longer.

This may emphasize the effectiveness of Simulation and Augmented Reality in science education. Alhumaidan et al. (2020) found that simulations enhance learners' comprehension of science complex concepts, problem-solving, and analytical skills by fostering inquiry and exploration. Similarly, Lin et al. (2020) reported that Augmented Reality significantly improves learners' conceptual understanding of systems like the human body and ecosystems. A meta-analysis by Cheng and Tsai (2021) also confirmed that both Simulations and Augmented Reality improve engagement and conceptual understanding, particularly when aligned with active learning strategies. These findings demonstrate that integrating these tools creates richer, more effective science learning experiences.

According to the DepEd Order No. 36, s. 2013, teaching and learning were the most important components of education. Appropriate use of the time and resources of learners and educators will have a beneficial effect on the learning process. Accordingly, as stated in DepEd Order No.78 s. 2010, the DepEd had already identified

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computerization programs as a key to changing education. These programs can equip public schools with appropriate technology to enhance the teaching and learning process and address the challenges of the twenty-first century. To meet the demands of the learners, education must investigate innovative techniques, creative strategies, and approaches.

As revealed in the latest National Achievement Test (NAT) in the Division of Bukidnon, Bukidnon ranked third to last with a Modified Performance Scale (MPS) result of 39.58%. This is less than the learners' performance proficiency target of the Division of Bukidnon, which is 86%, indicating a concerning trend; a significant portion of learners failed to meet proficiency levels, especially in problem-solving, information literacy, and critical thinking, signaling a significant challenge within the local education system.

At Salawagan National High School, Salawagan, Quezon, Bukidnon, senior high school science teachers utilize tools such as PowerPoint presentations, videos, audio, and engaging activities to enhance the learning journey of their learners. However, learners' academic performance in core science subjects like Earth and Life Science in HUMSS fell far below the national standard. In the most recent academic year, the average score for science stood at 53.87% on the MPS, well below the target minimum of 75%. This poor performance was identified as a potential factor contributing to the Division of Bukidnon's low standing in the NAT results. This observation indicated that a large number of learners face difficulties before starting senior high school, which may be related to their two years of modular distance learning (Leal, 2024).

This led to the development of lessons integrating Simulation and Augmented Reality as tools to enhance learners’ academic performance and active engagement in science. These technologies cater to diverse learning styles; visual learners benefit from interactive visuals, while kinesthetic learners engage through hands-on activities (Jarusevicius et al., 2024). Additionally, they allow students to learn at their own pace and revisit complex concepts, which is especially valuable for building strong foundations in advanced science learning (López & García, 2021).

Building on this, engagement plays a crucial role in the learning process. Active participation encourages learners to think critically, solve problems, and better understand complex science concepts, making it essential for effective science education. Engaged students develop a scientific mindset by analyzing data and drawing evidence-based conclusions, enabling them to overcome learning challenges more successfully (Wang & Eccles, 2013). Supporting this, Kim et al. (2022) found that hands-on, technology-supported activities significantly boost understanding, emphasizing that fostering engagement is key to developing scientific literacy and sustaining interest in science.

These tools could increase learners' engagement in science. Similarly, learners’ performance in school is predicted by their level of learning engagement. According to The Glossary of Education Reform (2016), the extent to which learners' focus, curiosity, enthusiasm, optimism, and passion are displayed during the learning process. One of the significant challenges facing parents and teachers today is getting learners involved in class activities and their academic work.

This study seeks to assess how the integration of Simulation and Augmented Reality technologies in Grade 11 Earth and Life Science can improve learners' academic performance and engagement. Simulation and Augmented Reality present innovative opportunities to address gaps in scientific understanding and learner engagement by providing interactive and immersive learning experiences. In evaluating the effect of these technologies, the study aims to offer insights into how these tools can be effectively implemented to enhance both academic performance and engagement, potentially contributing to a long-term improvement in the academic performance of learners in science subjects.

This study aims to determine the effects of Simulation and Augmented Reality on learners' academic performance and engagement in Grade 11 Earth and Life Science. Specifically, it seeks to answer the following questions:

- ➢ *What is the Level of Learners’ Academic Performance in Grade 11 Earth and Life Science When Taught Using:*

- Simulation
- Augmented Reality?

- ➢ *What is the Level of Learners’ Engagement in Grade 11 Earth and Life Science when Taught using Simulation and Augmented Reality, in Terms of:*

- Behavioral Engagement
- Cognitive Engagement
- Affective Engagement?

- ➢ *Is There A Significant Difference Between the Academic Performance of Learners in Grade 11 Earth And Life Science When Taught Using Simulation And Augmented Reality?*

- ➢ *Is There A Significant Difference Between Learners' Engagement in Grade 11 Earth And Life Science When Taught Using Simulation And Augmented Reality?*

II. LITERATURE REVIEW

- ➢ *Multimedia Instructional Tools and Academic Performance*

The integration of multimedia tools, particularly Simulation and Augmented Reality, has been widely acknowledged for transforming traditional classroom practices into more interactive and learner-centered environments. These tools support the development of critical thinking, conceptual understanding, and improved academic performance, especially in the sciences. Simulations replicate real-world scenarios, allowing

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students to manipulate variables and observe outcomes, thereby promoting deeper learning. Rutten et al. (2012), in a meta-analysis of 91 studies, found that simulations significantly improved academic achievement by enabling learners to engage in exploratory and experiential learning. Chernikova et al. (2020) similarly noted that simulations develop complex skills such as diagnostic reasoning and technical proficiency, particularly in higher education contexts.

Global studies have further confirmed the educational value of simulations. Frontiers in Education (2023) reported that learners who actively participated in simulation-based learning outperformed passive observers in terms of academic achievement and collaborative skills. Tandfonline (2023) also documented improvements in critical thinking and problem-solving among Colombian learners exposed to science simulations. Channegowda et al. (2025) emphasized the utility of simulations in enhancing understanding of biology and Earth science concepts, which translated into improved academic outcomes. In the Philippine context, Reyes and Garcia (2019) reported that senior high school students in Metro Manila who used simulations in biology demonstrated significantly higher examination scores than those taught using lecture-based methods. Similar results were observed by Bautista and Villanueva (2020), who found that environmental science learners in provincial schools improved their analytical skills and academic performance through simulation tools. Tan and Lopez (2017) also highlighted the role of simulation in strengthening conceptual understanding and problem-solving in STEM education. Furthermore, Ramos and Mendoza (2018) conducted a nationwide study confirming consistent improvements in science test scores across regions through simulation-integrated instruction.

Augmented Reality, on the other hand, enhances academic performance by overlaying digital content in real-world contexts, making abstract concepts more tangible and accessible. Cabero-Almenara and Marin-Diaz (2018) found that Augmented Reality promotes active learning and critical thinking among secondary learners. Amores-Valencia and De-Casas-Moreno (2020) further emphasized the personalized nature of Augmented Reality offering real-time feedback and adaptable content that supports individualized learning. Chen et al. (2023) and Martín-Gutierrez and Meneses-Fernandez (2024) also observed improved academic results and conceptual understanding among students using Augmented Reality tools. Liu and Zhao (2023) reported that Augmented Reality boosts learners' self-efficacy and motivation, while Fonseca-Escudero and Sanchez-Bolado (2020) documented higher knowledge retention in STEM subjects when Augmented Reality was integrated into instruction. Although Ibañez and Jerabek (2020) noted challenges such as internet access and implementation costs, they affirmed the pedagogical value of Augmented Reality. Zhao et al. (2023) also confirmed Augmented Reality's effectiveness through bibliometric analysis, indicating substantial academic gains in immersive learning environments. Despite the promise of Augmented Reality in education, few studies have explored its application in senior high school science. Thus, the present study seeks to address this gap by examining the academic impact of Augmented Reality on Grade 11 learners.

➢ *Multimedia Instructional Tools and Engagement*

Aside from improving academic outcomes, multimedia tools such as Simulation and Augmented Reality have shown strong potential in enhancing learner engagement—cognitively, emotionally, and behaviorally. Engagement is a vital component of the learning process, as it correlates with motivation, attention, and knowledge retention. Dela Cruz and Santos (2018) found that simulation applications significantly increased learner engagement in geology and environmental science. Garcia and Reyes (2022) noted that gamified simulations in Earth and Life Science fostered active participation among Philippine high school students. Similarly, Thompson et al. (2023) reported consistent engagement gains across science disciplines through simulation-based learning. Lim et al. (2024) observed that interactive simulations strengthened emotional connections in ecology lessons by allowing real-time manipulation of scientific variables.

Additional studies support the role of simulations in increasing learner satisfaction and active involvement. Alkhaldi et al. (2022) identified kinesthetic learning styles and self-confidence as key predictors of engagement in science simulations. In teacher education, Schmitt et al. (2025) reported that simulations enhanced pre-service teachers' diagnostic and cognitive engagement skills. Padgett et al. (2019) emphasized the role of behavioral, emotional, and cognitive engagement in healthcare simulations, while Hyland et al. (2025) outlined strategies to reduce anxiety and improve participation in pediatric simulations through well-structured activities. Chen and Wong (2020) demonstrated that mixed-reality simulations significantly improved learner engagement and conceptual understanding in Earth Science, particularly in visualizing complex geological processes.

Augmented Reality has similarly been recognized for its capacity to heighten engagement through multisensory, interactive learning experiences. Yu et al. (2022) noted that AR stimulates curiosity and fosters active learning. Nagata et al. (2017) showed that mobile AR applications enhanced behavioral engagement in STEM subjects, while Karacan and Akoglu (2021) reported increased emotional engagement in cultural education through immersive AR tools. Wen (2021) and Jesionkowska et al. (2020) found that AR environments accommodate diverse learning preferences, enhancing inclusivity and engagement. Abd Majid and Abd Majid (2018) demonstrated that AR applications in teaching atomic structure improved cognitive engagement by simplifying complex topics. Studies by Xie, Liu, and Parmaxi (2019), Erbas and Demirer (2019), and Ibáñez et al. (2020) highlighted the role of AR in promoting personalized feedback, collaborative learning, and increased learner interaction. Liu et al. (2023) concluded that AR-supported virtual science laboratories increased time-on-task and learner interaction with digital content.

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The reviewed literature establishes that Simulation and Augmented Reality are transformative instructional tools that enhance both academic performance and learner engagement. These technologies facilitate interactive, student-centered learning environments that are particularly effective in science education. The present study aims to further explore the effectiveness of these tools in the context of Grade 11 Earth and Life Science, contributing to the growing body of knowledge on multimedia-enhanced instruction.

III. METHODOLOGY

This study utilized a quasi-experimental design which involves comparing groups without random assignment to determine the effect of an intervention. This approach made it possible to evaluate learners' academic performance through pretests and posttests, as well as assess their engagement in Earth and Life Science among learners exposed to simulations and those exposed to Augmented Reality. The design allowed meaningful comparisons between these two groups in a real-world classroom setting.

The study was conducted at Salawagan National High School, Senior High School Department, Salawagan, Quezon, Bukidnon, is known for its diverse population of learners, with over 1,880 students enrolled. Of these, 606 were senior high school learners—305 in Grade 11 and 301 in Grade 12. The Senior High School Department offers the Academic Track, including the Science, Technology, Engineering, and Mathematics (STEM); Accountancy, Business and Management (ABM); and Humanities and Social Sciences (HUMSS) strands. It also offers the Technical-Vocational Livelihood (TVL) strands, with specializations in Electrical Installation and Maintenance (EIM), Home Economics (HE), and Information and Communications Technology (ICT).

The study involved two intact classes of Grade 11 HUMSS learners at Salawagan National High School, Salawagan, Quezon, Bukidnon, during the school year 2024–2025. One class, consisting of 30 learners, was exposed to Simulation, while another class of 30 learners was exposed to Augmented Reality. These two sections were randomly selected from the seven existing Grade 11 HUMSS sections. The use of intact classes preserved the natural classroom environment, maintaining authentic peer interactions and classroom dynamics. Prior to the implementation, both groups demonstrated comparable levels of academic performance, ensuring that any differences observed afterward could be attributed to the instructional tools used. It was also noted that several learners had visual learning preferences and responded positively to digitized and interactive activities.

Development of Lesson Plan Integrating Simulation and Augmented Reality

- *Design and Development*

This part discusses how learners used the Simulation and Augmented Reality in the Explore and Explain part of the lesson. It also contains:

- *Need Analysis*.

A needs analysis survey was conducted among senior high school science teachers handling Earth and Life Science at Salawagan National High School. The teachers were asked to identify the most challenging topics in the Department of Education Senior High School Earth and Life Science Curriculum Guide that would benefit from the integration of advanced instructional tools such as Simulation and Augmented Reality.

Based on the survey results, the top three complex topics identified were: Bioenergetics - Structures and Functions of Cells, Bioenergetics - Photosynthesis and Energy Flow, and Bioenergetics - Utilization of Energy. These topics fall within the K to 12 Curriculum Framework and are covered during the second semester. Their sequential arrangement ensures coherent conceptual progression and supports continuity in the learning process.

Although specific objectives were provided in the official modules, they were modified to match the learners' performance levels in the research context. Lessons and accompanying activities were then designed accordingly. This included the careful selection and preparation of appropriate online simulation platforms and augmented reality applications to enhance student engagement and improve understanding of complex biological processes.

- *Writing the Lessons.*

This stage includes writing the lesson using Simulation and Augmented Reality on Bioenergetics Structures and Functions of Cells, Bioenergetics Photosynthesis and Energy Flow, and Bioenergetics Utilization of Energy. The implementation, Simulation, and Augmented Reality activities will be included in the Explore and Explain section of the 7E lesson plan. The lesson had the following parts:

- *Elicit:*

The learners were given a pretest about the topic to be discussed. This assessment aimed to check whether they had prior knowledge about the topic. This helped the teacher understand the learners' existing knowledge and identify areas that needed focus during the lesson.

- *Engage*:

At the beginning of the lesson, learners were given a short activity designed to capture their curiosity and engage them in the upcoming lesson. This activity serves as a preparation for the main lesson, setting the stage for the learning experience.

- *Explore:*

At this stage, Simulation and Augmented Reality were used alongside activity worksheets, allowing learners to explore the topic through hands-on, interactive tasks.

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Simulation lets them investigate real-life scenarios in a digital setting, while augmented Reality adds visual elements to their real-world environment, making learning more engaging and immersive.

- *Explain*:

During this stage, each group discussed and explained their Simulation and Augmented Reality results. At the same time, the teacher provided additional information and presented the Simulation and Augmented Reality to address any missed concepts. This stage aimed to provide clear explanations and deepen the learners' understanding of the topic.

- *Elaborate*:

The learners were allowed to further understand the concept through a short game-based activity, trivia, or additional information. This stage encouraged applying knowledge in new and challenging situations, promoting a more profound understanding.

- *Evaluate*:

To assess the knowledge acquired throughout the lesson, learners were given a posttest. This assessment aimed to gauge the effectiveness of the lesson and the learners' grasp of the material.

- *Extend*:

In this stage, learners were given tasks to apply the concepts they had learned, such as a project-based activity, to enhance creativity and critical thinking skills and reinforce their understanding of the topic.

This study employed two primary instruments: a researcher-made academic performance test and a learner engagement questionnaire. The academic performance test consisted of 60 multiple-choice items covering three major topics in Bioenergetics: Structures and Functions of Cells, Photosynthesis and Energy Flow, and Utilization of Energy.

These topics were aligned with the learning competencies outlined in the K–12 Curriculum Guide for the second semester. After pilot testing with Grade 12 students, 60 items were selected based on reliability analysis. The original 100-item version yielded a Kuder-Richardson (KR-20) reliability coefficient of 0.895, indicating strong internal consistency.

The second instrument was a 30-item learner engagement questionnaire adapted from Attard (2012), designed to measure three dimensions of engagement: behavioral, affective, and cognitive. Each component included 10 items rated on a four-point Likert scale: Always, Usually, Sometimes, and Never. The questionnaire was modified to fit the context of science education and was validated for use in this study. The instrument showed excellent internal consistency, with a Cronbach's Alpha of 0.986. This engagement scale was used to gather data on learners' attitudes, behaviors, and cognitive involvement in science learning activities.

To ensure accurate and reliable findings, appropriate statistical treatments were applied. The mean and standard deviation were computed to determine the academic performance and engagement levels of Grade 11 Earth and Life Science learners exposed to Simulation and Augmented Reality. To compare the academic performance of the two groups, a one-way analysis of covariance (ANCOVA) was conducted at a 0.05 level of significance. In addition, an independent samples t-test was used to assess differences in learners' engagement between the Simulation and Augmented Reality groups.

IV. PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

Table 1 Pretest and Posttest Performance Distribution of Learners Exposed To Simulation and Augmented Reality

Level of Performance	**Score**	**Simulation**						**Augmented Reality**					
		Pretest			**Post test**			**Pretest**			**Post test**		
		f	x̄	%	*f*	x̄	%	*f*	x̄	%	*f*	x̄	%
Outstanding	54-60	0	0	0	0	0	0	0	0	0	0	0	0
Very Satisfactory	51-53	0	0	0	1	54	3.3	0	0	0	2	52.50	6.7
Satisfactory	48-50	0	0	0	2	49	6.7	0	0	0	4	48.67	13.3
Fairly Satisfactory	45-47	0	0	0	4	49	13.3	0	0	0	4	46.50	13.3
Did not meet the expectation	Below 45	30	22.74	100	23	36.79	76.7	30	22.54	100	20	34.96	66.7
Mean		22.74			38.69			22.54			37.89		
SD		6.41			5.88			6.68			7.76		
Level of Performance		DE			DE			DE			DE		

Legend:
O = Outstanding,
VS = Very Satisfactory,
S = Satisfactory,
FS = Fairly Satisfactory,
DE = did not meet the Expectation.

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Prior to the intervention, all 30 learners in the simulation group were categorized as *did not meet the expectation*, with a mean score of 22.74 and a standard deviation of 6.41, indicating a relatively low and varied performance. Following the intervention, there was a notable improvement in academic performance; only 23 learners remained in the did not meet the expectation category, while four moved up to *Fairly Satisfactory*, two to *Satisfactory*, and one to *Very Satisfactory*, and no learner reached the *Outstanding level*. The posttest mean score increased significantly to 38.69, while the standard deviation decreased to 5.88, indicating that the simulation instruction not only improved academic performance but also promoted greater consistency among learners.

Similarly, all 30 learners in Augmented Reality scores are categorized as *did not meet the expectation* in the pretest, with a mean score of 22.54 and a standard deviation of 6.68. After the intervention, their performance improved, though slightly less than the simulation group; 20 learners *did not meet the expectation*, while four advanced to *Fairly Satisfactory*, four to *Satisfactory*, and two to *Very Satisfactory*, and none reached the Outstanding level. The posttest mean score increased to 37.89, with an increased standard deviation of 7.76, indicating an improvement but more variation in academic performance.

Both instructional approaches, Simulation and Augmented Reality, resulted in significant improvements in learners' performance from the pretest to the posttest. However, the slightly higher posttest mean in the simulation group suggests that simulation-based learning may offer a more structured and predictable environment, resulting in a more consistent impact on learners' performance. The use of a tool that allows manipulation and visualization of scientific variables likely contributed to a deeper understanding of complex topics.

The slightly higher posttest mean in the simulation group may be attributed to learners' prior exposure to simulation tools during junior high school, which likely enhanced their comfort and preparedness in the use of technology. However, despite this advantage, many learners still did not meet expectations, possibly due to the difficulty of the subject matter and the group setup. Working in triads may have posed challenges for some learners who prefer individual tasks or struggle with group dynamics (Channegowda et al.,2025).

The slight decrease in standard deviation and the higher posttest mean in the simulation group indicate that simulation-based learning contributed to more consistent academic performance and better conceptual understanding. This finding supports the study by Frontiers in Education (2023), which highlighted how simulations offer structured feedback and help learner's correct mistakes and achieve uniform learning outcomes.

Similarly, Tandfonline (2023) reported that simulation-based learning improved learners' analytical reasoning and problem-solving, leading to more stable performance. Ramos and Mendoza (2018) also emphasized that simulations help learners grasp complex science topics by allowing them to manipulate and observe variables directly.

On the other hand, the wider variation in the Augmented Reality group's posttest scores suggests that, while Augmented Reality was engaging, it may have presented challenges for learners who were unfamiliar with the technology. Fonseca-Escudero and Sánchez-Bolado (2020) noted that the lack of experience with Augmented Reality tools could affect learners' learning, especially when the topic is complex and the group setup may not suit all learners.

While the Augmented Reality group exhibited slightly lower mean gains compared to the simulation group, the broader range of scores indicates that Augmented Reality offered a highly engaging learning experience for some learners, yet posed adaptability challenges for others. Many learners were visibly excited and amazed by the immersive nature of Augmented Reality, which allowed them to interact with digital elements in their real environment. This novelty sparked enthusiasm and initial engagement.

However, this excitement did not consistently translate into a deeper understanding, likely because most learners were using Augmented Reality tools for the first time. The unfamiliarity may have increased cognitive load, making it harder to process complex information (Rutten et al., 2012). Additionally, the difficulty of the topic and the group setup may have limited comprehension for learners who benefit from working individually or need more structured guidance when using unfamiliar technologies (Chernikova et al., 2020).

Despite the increase in mean scores, the high posttest and standard deviation in the Augmented Reality group exhibit varied comprehension levels. While some learners benefited from the immersive experience, others struggled with adaptability, particularly those unfamiliar with the technology. Liu and Zhao (2023) noted that Augmented Reality enhances engagement but may pose challenges for learners with limited exposure.

Similarly, Ibáñez and Jerábek (2020) identified barriers such as accessibility and technological literacy that could impact Augmented Reality's effectiveness. Martín-Gutiérrez and Meneses-Fernández (2024) also highlighted that Augmented Reality's impact varies based on learners' comfort with digital tools, which likely explains the broader range of posttest scores in the Augmented Reality group compared to the more consistent results in the Simulation group.

The findings of this study indicate that both Simulation and Augmented Reality are practical instructional tools for improving learners' academic performance in Grade 11 Earth and Life Science. The significant increase in posttest scores in both groups demonstrates the efficacy of these technologies in enhancing learners' learning. While simulation-based learning provides a more consistent and

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structured learning environment, Augmented Reality fosters engagement and interactivity, though with a greater range of individual performance outcomes. These results align with the broader body of research emphasizing the role of technology-driven instructional methods in promoting academic success.

Table 2 Learners' Engagement in Simulation and Augmented Reality in Terms of Behavioral Engagement

	Simulation	**Augmented Reality**				
Indicators	x	SD	*QD*	x	SD	*QD*
I am listening to the teacher's discussion during ELS class.	3.57	0.61	HE	3.77	0.49	HE
I am doing the seatwork given by the ELS teacher in class.	3.42	0.70	HE	3.22	0.69	AE
I stand up and answer my teacher's questions when called in ELS class.	3.11	0.72	AE	3.11	0.83	AE
I am raising my hands whenever I know the answer.	3.05	0.76	AE	3.02	0.92	AE
I am doing my assignment in ELS.	3.71	0.52	HE	3.14	0.81	AE
I am raising my hands and asking questions whenever I have queries about the lesson presented in our ELS class.	2.94	0.73	AE	2.77	0.94	AE
I am actively participating in the different activities in our ELS class.	3.31	0.72	HE	2.88	0.87	AE
I am studying my lessons at home Whenever there is a test in ELS class.	3.31	0.72	HE	2.91	0.89	AE
I am writing down notes in my ELS class.	3.48	0.66	HE	3.28	0.71	HE
I am doing my ELS projects creatively and submitting them on time.	3.40	0.74	HE	3.31	0.71	HE
Mean	**3.33**	**0.69**	**HE**	**3.14**	**0.79**	**HE**

Legend:

Range	Qualitative Description
3.25-4.00	High Engagement (HE)
2.50-3.24	Average Engagement (AE)
1.75-2.49	Low Engagement (LE)
1.00-1.74	No Engagement (NE)

As can be gleaned from the indicator, I am doing my assignment in ELS recorded the highest mean score in the simulation environment, with a mean of 3.71 and a standard deviation of 0.52, indicating a high level of behavioral engagement. In comparison, this same indicator under Augmented Reality recorded a mean of 3.14 with a standard deviation of 0.81, which falls under average engagement. This suggests that simulation may be more effective in motivating learners to complete assignments, possibly due to its structured, hands-on nature that allows learners to directly interact with content during class. The higher engagement in this context may also reflect the familiarity learners have with simulation tools, which often involve task-based manipulation aligned with classroom activities.

Moreover, the indicator I am listening to the teacher's discussion during ELS class recorded the highest mean score in the augmented reality environment, with a mean of 3.77 and a standard deviation of 0.49, indicating a high level of behavioral engagement. This same indicator under the simulation environment recorded a mean of 3.57 with a standard deviation of 0.61, also categorized as high engagement. This suggests that augmented reality may be particularly effective in capturing learners' attention during discussions, possibly due to its immersive and visually stimulating features that enhance the learning experience. The heightened engagement in listening during Augmented Reality-based lessons could also stem from the novelty and interactive appeal of augmented content, which may prompt learners to focus more closely on teacher instructions to fully understand and interact with the digital enhancements integrated into the lesson.

Conversely, the indicator with the lowest mean score in Augmented Reality was I am raising my hands and asking questions whenever I have queries about the lesson presented in our ELS class, with a mean of 2.77 and a standard deviation of 0.94. Simulation also scored low on this same indicator, with a slightly higher mean of 2.94 and a standard deviation of 0.73, indicating only average engagement. This suggests that neither instructional tool significantly promotes spontaneous verbal participation. A possible explanation is that learners may hesitate to speak up, potentially due to a lack of confidence in the subject matter. This is particularly plausible if the learners are from non-STEM strands, who may not view science as their primary academic focus.

The results indicate that learners show higher behavioral engagement with Simulation-based instruction, which has a mean score of 3.33, compared to Augmented Reality, with a mean score of 3.14. Although both tools are effective in promoting engagement, Simulation appears to support more consistent and active classroom behavior. This may be due to its interactive and gamified nature, allowing learners to manipulate variables and see immediate outcomes, which enhances their involvement and excitement. On the other hand, while Augmented Reality also offers engaging elements like 3D object interaction, its impact may be limited by technical difficulties or students'

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unfamiliarity with the tool, potentially leading to reduced participation or distraction.

It is important to note that learners' behavioral engagement significantly influences academic performance by enhancing participation and attentiveness in learning activities. This study supports Thompson et al. (2023), who found that simulation-based learning consistently improves engagement across science disciplines. Its interactive nature, allowing learners to manipulate variables and observe outcomes in real time, encourages sustained involvement (Lim et al., 2024). Similarly, Alkhaldi et al. (2022) observed that the hands-on features of simulations promote active engagement in subjects like physics, chemistry, and biology.

Conversely, while Augmented Reality still fosters engagement, its slightly lower mean score may be due to technical challenges or learners' limited familiarity with the tool. For many, using Augmented Reality is a new experience, which can lead to hesitation or distraction as they navigate unfamiliar features. Unlike Simulations that resemble familiar games or experiments, Augmented Reality introduces novel interactions that are not always intuitive. This can affect focus and sustained participation. Jesionkowska et al. (2020) emphasize that although AR supports diverse learning styles, its impact relies heavily on learners' adaptability and comfort with the technology.

Table 3 Learners' Engagement in Simulation and Augmented Reality In Terms of Cognitive Engagement

	Simulation	**Augmented Reality**				
Indicators	**x**	**SD**	**QD**	**x**	**SD**	**QD**
I am looking forward to learning more about ELS.	3.11	0.47	AE	3.00	0.87	AE
I read my ELS book in advance to be ready for our class.	2.80	0.63	AE	2.57	0.78	AE
I devote my time to practice lessons in ELS after school.	3.14	0.73	AE	2.62	0.88	AE
I am thinking a lot in ELS class.	3.22	0.59	AE	3.08	0.82	AE
In my free time, I look for more information on topics discussed in ELS class.	2.91	0.74	AE	2.88	0.90	AE
Whenever I am absent in class, I am asking my classmates to help me understand my missed ELS lesson.	3.51	0.66	HE	3.22	0.84	AE
I recognize the value of learning in our ELS class.	3.25	0.74	AE	3.17	0.71	AE
I am investing time and effort to learn a lot in our ELS lessons.	3.22	0.69	AE	3.00	0.80	AE
I have to stay up late at night to study our lessons in ELS.	2.88	0.63	AE	2.74	0.81	AE
I am trying to learn as much as I can in our ELS class.	3.22	0.84	AE	3.14	0.81	AE
Mean	**3.13**	**0.67**	**AE**	**2.94**	**0.82**	**AE**

Legend:

Range	Qualitative Description
3.25-4.00	High Engagement (HE)
2.50-3.24	Average Engagement (AE)
1.75-2.49	Low Engagement (LE)
1.00-1.74	No Engagement (NE)

The table reveals that among the indicators, the highest level of cognitive engagement in both Simulation and Augmented Reality is observed in learners' willingness to seek help from classmates when they miss a lesson. Learners exposed to Simulation have a mean score of 3.51 and a standard deviation of 0.66, while learners exposed to augmented Reality have a mean of 3.22 and a standard deviation of 0.84. This indicates that learners recognize the importance of staying updated with their lessons and actively seek peer support to ensure continuity in their learning, especially lessons that use Simulation and Augmented Reality, which makes them want to fit into the learning process.

On the other hand, learners exposed to Augmented Reality have the lowest mean in reading the Earth and Life Science book in advance, with a mean score of 2.57 and a standard deviation of 0.78. The Simulation group records the lowest mean score of 2.80, with a standard deviation of 0.68; the same values are observed in the augmented reality group. Moreover, simulation-based learners report a higher mean in class preparation, as they more frequently read the Earth and Life Science textbook in advance compared to those using Augmented Reality. This suggests that simulation environments may promote a more proactive approach to learning.

The overall mean result indicates that learners generally exhibit a higher level of cognitive engagement when using Simulation, with a mean of 3.13 and a standard deviation of 0.67, compared to Augmented Reality, with a mean of 2.94 and a standard deviation of 0.82. Both approaches fall within the Average Engagement category, signifying that learners are moderately engaged in Earth and Life Science regardless of the technology used. However, Simulation appears to foster a slightly stronger cognitive engagement.

The greater overall standard variation in Augmented Reality cognitive engagement may be attributed to individual differences in how learners interact with and perceive augmented reality learning. In contrast, simulation-

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based learning provides a more stable and predictable level of cognitive engagement, potentially due to its structured nature and familiar learning approach.

The results agree with the idea of Yu et al. (2022) that interactive simulations significantly improved learners' retention and recall rates, particularly in STEM subjects. Similarly, Dela Cruz and Santos (2018) identified self-confidence and kinesthetic learning styles as key predictors of engagement in simulation-based learning, suggesting that structured digital environments facilitate cognitive engagement more effectively than Augmented Reality.

While Augmented Reality supports cognitive engagement by visualizing complex concepts, its lower mean score may stem from limited scaffolding compared to simulations (Abd Majid & Abd Majid, 2018). Though engaging, Augmented Reality may lack the guided structure learners need. Xie, Liu, and Parmaxi (2019) also note that personalized feedback in Augmented Reality can enhance cognitive engagement, but its effectiveness depends on how well such features are integrated.

Table 4 Learners' Engagement in Simulation and Augmented Reality in Terms of Affective Engagement

	Simulation	**Augmented Reality**				
Indicators	x	SD	QD	x	SD	QD
I like the feeling when I am answering activities.	3.11	0.76	AE	2.97	0.78	AE
I help my classmates with answering questions whenever they have difficulties.	3.05	0.76	AE	2.91	0.76	AE
I am sharing my ideas and notes with my classmates in ELS.	3.40	0.69	HE	3.05	0.69	AE
I am trying my best not to be absent in ELS class.	3.65	0.59	HE	3.22	0.59	AE
I am happy that my teacher in ELS encourages me to be involved in class.	3.62	0.49	HE	3.57	0.49	HE
I am glad that my classmates are willing to help me in answering ELS activities.	2.62	0.69	HE	3.17	0.69	AE
I like the way my ELS teacher delivers the lesson in class.	3.74	0.44	HE	3.54	0.44	HE
My ELS teacher tries her best for me to learn.	3.85	0.36	HE	3.57	0.36	HE
I enjoyed the activities in our class.	3.62	0.55	HE	3.28	0.55	HE
I am not bored in our ELS class.	3.22	0.69	AE	3.17	0.69	AE
Mean	**3.49**	**0.60**	**HE**	**3.24**	**0.60**	**AE**

Legend:

Range	Qualitative Description
3.25-4.00	High Engagement (HE)
2.50-3.24	Average Engagement (AE)
1.75-2.49	Low Engagement (LE)
1.00-1.74	No Engagement (NE)

As shown, learners in the simulation group reveal the highest mean score for the indicator that the teacher tries her best for them to learn, with a mean of 3.85 and a standard deviation of 0.36. Similarly, the Augmented Reality group also records a high mean for the same indicator, at 3.57, with a standard deviation of 0.36. This result suggests that Simulation may provide a more structured and immersive learning experience that effectively captures learners' curiosity and enhances their emotional connection to the lesson because, as they change variables, they get a direct result that makes them more engaged, and in Augmented Reality, it indicates slightly reduced engagement levels.

In addition, the lowest mean score in the simulation group is the indicator I am glad that my classmates are willing to help me in answering ELS activities with a mean score of 2.62 and a standard deviation of 0.69. This suggests that while Simulation is engaging, it may promote more independent learning rather than collaborative interaction. The nature of simulation-based tasks often requires individual problem-solving, which can limit peer assistance. Furthermore, since the study was conducted in groups of three, group size may have influenced the dynamics of smaller groups, which can reduce opportunities for broader collaboration, especially when each member is focused on manipulating and interpreting the Simulation individually.

Additionally, Augmented Reality shows the lowest mean-to-standard deviation indicator related to helping classmates, with a mean of 2.91 and a standard deviation of 0.76, suggesting that learners may not frequently assist their peers while using Augmented Reality. This may be attributed to the individual-focused nature of augmented reality activities, where learners tend to become more absorbed in their own augmented experiences rather than actively participating in cooperative problem-solving.

The findings suggest that both Simulation and Augmented Reality enhance learners' affective engagement, with Simulation providing a more consistently enjoyable and immersive experience. Its structured and interactive nature better supports emotional and social connection during learning. However, Augmented Reality also shows potential, particularly in encouraging learners when guided by teachers. These results are consistent with Chen and Wong (2020), who found that mixed-reality simulations increase affective engagement by creating more immersive and emotionally engaging learning environments.

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In contrast, while Augmented Reality also fosters emotional engagement, it may not always sustain the same level of engagement. This is consistent with the findings of Wen (2021), who noted that while Augmented Reality activities increase learners' involvement and engagement, they are most effective when customized to the learners' specific learning contexts. Additionally, Erbas and Demirer (2019) observed that gamified Augmented Reality environments significantly enhance learners' engagement, suggesting that the inclusion of gamification elements could further strengthen Augmented Reality's affective engagement potential.

Table 5 Overall Learner's Engagement in Earth and Life Science

	Simulation	**Augmented Reality**				
Indicators	x	SD	QD	x	SD	QD
Behavioral	3.33	0.69	HE	3.14	0.79	AE
Cognitive	3.13	0.67	AE	2.94	0.82	AE
Affective	3.49	0.60	HE	3.24	0.66	AE
Overall Mean	**3.32**	**0.65**	**HE**	**3.11**	**0.76**	**AE**

Legend:

Range	Qualitative Description
3.25-4.00	High Engagement (HE)
2.50-3.24	Average Engagement (AE)
1.75-2.49	Low Engagement (LE)
1.00-1.74	No Engagement (NE)

The table highlights the engagement levels of learners in Earth and Life Science when utilizing Simulation and Augmented Reality. It was measured across three key domains: behavioral, cognitive, and affective, with corresponding means and standard deviations recorded for each.

In terms of behavioral engagement, the results show that learners consistently engage in Simulation, with a mean of 3.33 and a standard deviation of 0.69, indicating High Engagement. In contrast, the engagement with Augmented Reality is categorized as Average engagement, with a mean of 3.14 and a standard deviation of 0.79. This suggests that learners exhibit a higher degree of participation, persistence, and involvement in learning activities when using simulation-based tools. The structured and interactive nature of simulations might encourage students to take active roles in experimentation, problem-solving, and decision-making, leading to sustained behavioral engagement.

Conversely, while Augmented Reality demonstrates an average level of engagement, its slightly lower mean score could imply that certain challenges, such as technical difficulties, or that the learners are less familiar with the tool. The varying levels of learners' comfort with digital tools, especially when administered in groups, may affect learners' sustained involvement.

For cognitive engagement, the results indicate that learners show average engagement both in Simulation, with a mean of 3.13 and a standard deviation of 0.67, and in Augmented Reality, with a mean of 2.94 and a standard deviation of 0.82. However, the slightly higher mean score for Simulation suggests that learners tend to be more mentally engaged and actively process information better when using simulations compared to Augmented Reality. This could be attributed to the structured nature of simulations, which often provide guided exploration, step-by-step instructions, and controlled environments that facilitate deeper cognitive processing.

On affective engagement, learners showed average engagement in Simulation with a mean score of 3.49 and a standard deviation of 0.60, and average engagement in Augmented Reality with a mean of 3.24 and a standard deviation of 0.66. The results suggest that learners tend to feel more emotionally connected, motivated, and interested in learning when using Simulations compared to Augmented Reality. The highly effective engagement in simulations could be due to the familiar and structured nature of these tools, which provide a clear sense of progression and accomplishment. This may be due to the structured and predictable nature of simulations, which allow learners to engage deeply without external distractions or technical barriers (Schmitt et al., 2025).

The findings from Ibáñez et al. (2020) further reinforce this conclusion, as they found that learners demonstrated higher behavioral and cognitive engagement when working collaboratively using Augmented Reality tools. Similarly, Liu et al. (2023) analyzed virtual science labs powered by Augmented Reality technologies. They found that Augmented Reality-enhanced environments significantly improved learners' interaction with digital content, though engagement levels varied depending on the complexity of the tool.

Table 6 Summary of the Learners' Academic Performance Scores in Science

Source of Variation	**Type III Sum of Squares**	**Df**	**F-value**	**p-value**	**Partial Eta Squared**
Corrected Model	1110.378	2	17.514	.000	.343
Group	8.025	1	0.253	.617	.004
Error	2123.908	67			
Total	67440.000	70			

*Significant at $p<0.05$ alpha level

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As can be seen, the Group variable, which represents the different instructional methods, has a Type III Sum of Squares of 8.025, an F-value of .253, and a p-value of .617. Since the p-value is greater than .05, it is not statistically significant, suggesting that Simulation and Augmented Reality do not result in a meaningful difference in learners' academic performance. Furthermore, the Partial Eta Squared of .004 indicates that the group classification accounts for only 0.4% of the variance in performance, reinforcing the conclusion that instructional methods have similar effects on learning.

The findings suggest that both Simulation and Augmented Reality are equally effective in enhancing learners' science learning. The lack of significant difference between the two tools indicates that either approach can be used to support learning. This supports the idea that technology-enhanced learning tools, whether simulation-based or augmented reality-based, offer meaningful educational benefits. Given the nature of science as a subject that values both visual representation and interactive exploration, both tools are well-suited for instruction. The choice between Simulation and Augmented Reality can be guided by teacher preference, accessibility, or classroom context rather than concerns about which is more effective.

This supports the findings of Tan and Lopez (2017), who showed that senior high school STEM students using simulations scored higher than those taught through traditional methods. Similarly, Reyes and Garcia (2019) found that Metro Manila students using simulations in biology performed better on exams than those taught by lecture. Bautista and Villanueva (2020) also reported that learners in environmental science simulations showed improved analytical skills and higher grades compared to textbook-only learners.

Similarly, Augmented Reality has been shown to boost academic performance by increasing engagement and interactivity. Cabero-Almenara and Marín-Díaz (2018) emphasized its role in promoting active learning, while Amores-Valencia and De-Casas-Moreno (2020) found it enhances achievement through real-time feedback and interactive content. A systematic review by Cabero-Almenara and Barroso-Osuna (2018) concluded that Augmented Reality significantly improves motivation and academic outcomes. More recent studies by Chen et al. (2023) and Zhao et al. (2023) further confirmed its effectiveness in enhancing conceptual understanding and supporting STEM learning.

Ultimately, the study supports the conclusion that both Simulation-based learning and Augmented Reality are practical pedagogical tools, but neither is characteristically superior in improving academic performance. The results indicate that educators can integrate either method based on preference, accessibility, and contextual needs rather than effectiveness concerns. This aligns with previous findings that technology-enhanced learning, whether through Simulation-based learning or Augmented Reality, provides meaningful educational benefits and supports learning in science education.

Table 7 Test of the Difference of Learners’ Engagement in Science

Group	**df**	**Mean**	**F**	**p**
Behavioral	2	1.304	2.922	.061
Cognitive	2	1.315	2.876	.063
Affective	2	1.037	2.603	.082
Overall			**2.800**	**.069**

*Significant at p<0.05 alpha level

The data were screened and verified to determine whether they met the one-way independent t-test assumptions. The data indicate that there is no statistically significant difference in learners' engagement in Earth and Life Science across the behavioral, cognitive, and affective domains, as well as in overall engagement. The p-values for all engagement indicators are greater than 0.05, signifying that the differences observed between the groups are not statistically significant, as the mean values are relatively close to each other. No significant differences were found; these results suggest that both Simulation and augmented Reality are equally effective in fostering learners' engagement in science education.

Further, no significant difference was observed between the two instructional approaches in terms of behavioral engagement, with an F value of 2.922 and a p-value of .061. This implies that both Simulation and Augmented Reality effectively encourage learners to participate actively in science-related activities, follow instructions, and engage in learning tasks with equal enthusiasm. The results suggest that regardless of whether learners are using Simulation-based learning or Augmented Reality-enhanced instruction, they remain consistently involved in hands-on tasks and interactive learning experiences.

These findings align with Garcia and Reyes (2022), who found that gamified simulations in high school science classes improved learners' behavioral engagement. Additionally, Nagata et al. (2017) emphasized that Augmented Reality applications encourage active participation in STEM tasks, further supporting the notion that both Augmented Reality and Simulations enhance learners' engagement in scientific learning activities.

Similarly, for cognitive engagement with an F value of 2.876 and a p-value of .063, the findings indicate no significant difference between the two tools. This suggests that both instructional strategies support learners' understanding of scientific concepts, critical thinking, and problem-solving skills at comparable levels. The

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effectiveness of both methods in facilitating cognitive engagement indicates that learners are able to comprehend and process scientific information effectively, whether they are learning through Simulation or Augmented Reality-based instruction.

In terms of affective engagement, the F value of 2.603 and p-value of .082 also indicate no significant difference, highlighting that both approaches generate similar levels of interest, motivation, and emotional involvement in science learning. Since affective engagement plays a crucial role in shaping learners' attitudes toward learning, this finding implies that both methods create an equally engaging and enjoyable learning environment.

The overall engagement results of an F value of 2.800 and a p-value of .069 confirm that the combined effects of behavioral, cognitive, and affective engagement do not differ significantly between the two groups. This reinforces the idea that both Simulation and Augmented Reality can be considered equally effective in promoting learners overall engagement in science education.

Padgett et al. (2019) defined engagement in simulation-based learning as multidimensional, emphasizing the importance of behavioral, cognitive, and emotional involvement. Similarly, Hyland et al. (2025) stressed the need for transparent learning objectives in simulations to maintain learners' engagement. Furthermore, Karacan and Akoglu (2021) also reported that Augmented Reality-enhanced virtual science labs significantly improve learners' interaction with digital content, further validating the equivalence of Simulation and Augmented Reality in fostering engagement.

V. SUMMARY, FINDINGS

➢ *Summary*

This study evaluates the effects of Simulation and Augmented Reality on the academic performance and engagement of Grade 11 learners in the Earth and Life Science subject. The study was conducted in Salawagan National High School, Division of Bukidnon, Region X, during the second semester of the school year 2024-2025. The study employed a quasi-experimental research design and a random sampling technique. The 30 learners in each group participated in the study, with one group taught using Simulation, and the other group was taught using Augmented Reality.

A validated 60-item academic performance test covering Bioenergetics Structures and Functions of Cells, Bioenergetics Photosynthesis and Energy Flow, and Bioenergetics Utilization of Energy was used to measure the academic performance of Grade 11 learners. The test was validated by a panel of experts. To assess learners' engagement in Earth and Life Science, the study employed the Learners' Engagement Questionnaire adapted from Attard (2012). This was administered after the implementation of Simulation and Augmented Reality supported activities in the lesson. The data on the academic performance and engagement in Grade 11 Earth and Life Science were treated using mean and standard deviation. One-way ANCOVA at 0.05 significant difference level was used to test the null hypothesis of a significant difference in academic performance. A one-way independent t-test at a 0.05 significance level was used to test the null hypothesis of a significant difference in engagement.

➢ *Findings*

Based on the collected and treated data, the following were the foremost findings of the study:

- Simulation and Augmented Reality improved learners' academic performance. Learners who used the Simulation generally attained higher overall scores, indicating that it improves performance immensely for some learners. On the other hand, those taught using Augmented Reality produced slightly more varied responses, suggesting that while it engages learners, the impact on performance may differ more widely among individuals.

- Simulation is more effective for enhancing learners' engagement in Earth and Life Science compared to Augmented Reality. Although Augmented Reality remains an engaging and innovative tool, it resulted in a slightly lower mean score compared to Simulation.

- Simulation and Augmented Reality are equally effective in enhancing learners' academic performance. The absence of significant difference between Simulation and Augmented Reality suggests that either approach can be confidently used to support student learning.

- There is no statistically significant difference between Simulation and Augmented Reality, indicating that both are effective tools for enhancing learners' engagement in Grade 11 Earth and Life Science.

VI. CONCLUSION

➢ *From the Findings, the Following Conclusions Were Drawn.*

- Both Simulation and Augmented Reality Improved learners' academic performance. Simulation generally led to higher scores, helping more learners move beyond struggling with fundamental knowledge and skills in science. While Augmented Reality showed more varied outcomes, suggesting it may benefit learners differently depending on their readiness and familiarity with the tool.
- Learners exposed to Simulation showed higher levels of engagement, suggesting deeper involvement and focus during learning activities. At the same time, Augmented Reality offered a highly interactive and visually rich experience, though learners' engagement varied across individuals.

- Simulation and Augmented Reality are equally effective in supporting academic performance. Either method may enhance science learning, depending on classroom needs and resources.
- Simulation and Augmented Reality are equally effective in promoting learners' engagement, involvement, and interaction in Grade 11 Earth and Life Science. This suggests that either tool can successfully foster active involvement in the learning process.

RECOMMENDATION

➢ *In Light of The Conclusions of the Study, The Following Recommendations Are Put Forth:*

- Learners may be encouraged to consistently use Simulation and Augmented Reality as part of their learning process to allow more time for adaptation and to fully benefit from these tools, ultimately enhancing their academic performance and engagement in Earth and Life Science.
- Teachers, especially Science Teachers, may use Simulation and Augmented Reality to foster positive engagement in learning science as they cater to different learning styles and preferences. These tools are visually engaging and interactive, helping learners grasp abstract scientific concepts more effectively.
- The Division of Bukidnon administrators may provide more support to teachers by integrating Simulation and Augmented Reality in the teaching of science. The use of these instructional tools may be included in the In-Service Training (InSET) and is suggested to be included in the school Learning Action Cells (SLAC).
- Science Education Programs may effectively utilize Simulation and Augmented Reality by developing additional resources and learning materials that would encourage engagement in different ways learners want to learn, considering the individual learning styles.
- Future studies may consider exploring more features of Simulation and Augmented Reality and evaluating the learning preferences of learners to strengthen learners' academic performance and engagement in learning science.

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