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Application of Augmented Reality in Collaborative Learning towards Enhancing Scientific Literacy of Grade 9 Students

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Abstract— Enhancing the scientific literacy of students is necessary as it provokes their curiosity and creativity leading to the emergence of new professionals who are geared towards innovative solutions to current problems. Thus, this study aimed to assess the effectiveness of utilizing augmented reality in collaborative learning strategies to enhance students' scientific literacy. A quasi-experimental research design was employed using two groups of Grade 9 Junior high school students. The instructional delivery was guided by a lesson plan and activity sheet that incorporated augmented reality in collaborative learning strategies. To assess the impact of these strategies on scientific literacy, pre-test and post-test assessments were conducted. In addition, the t-test was employed to ascertain any significant difference that may exist between the augmented reality in two separate collaborative learning methodologies. The results revealed a notable difference in the post-test scores of the two groups of respondents in terms of context and knowledge in the field of scientific literacy. Thus, the teacher can employ project-based learning, bolstered by augmented reality, to enrich students' understanding and proficiency in scientific literacy. Furthermore, the study also found a substantial difference between the pre-test and post-test results of the participants in all areas of scientific literacy when exposed to two separate collaborative learning strategies facilitated by augmented reality. Therefore, educators should contemplate integrating augmented reality into the classroom to bolster collaborative learning practices.

Keywords— Augmented reality, Project-based learning, Scientific literacy, Snowball learning.

INTRODUCTION

Education remains a foundation of prosperity and continuous development in times of subsequent changes. Instructors can shape the future as they are consistently devising and inventing better methods of teaching and learning to ensure every learner is equipped for the challenges of life and work. It is the mission of teachers to offer students diverse instructional ideas guided by their different skills and interests. They have to be creative and find means to reach all of the students in the most effective and engaging ways.

One notable feature of current-day learners is that they are mostly very technology- oriented as most of them grew up in a digital environment. They are skilled at efficiently using and navigating traditional and digital media tools. Using augmented reality in the teaching-learning process is an innovative and tech-related approach that is fit for 21st- century learners.

Augmented reality is an educational tool that replicates real-world settings using digital visual components such as photos, texts, movies, and 3D objects displayed on devices such as smartphones and tablets (Hayes, 2022). When

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a user directs the object towards an item or code, the computer vision system analyzes the video stream to recognize it. The user can observe both the physical object and the digital information generated by augmented reality (AR) software in a three-dimensional format. This combination results in a novel aesthetic and a seamless integration of the user's experience.

Integrating augmented reality into collaborative learning provides an opportunity to greatly enhance the educational experience (Sereno, et al., 2020; Lukosch, 2015; Pidel and Ackermann, 2020). Collaborative learning is an educational method where students actively participate in group activities and cooperate to effectively accomplish shared learning objectives. Collaborative learning involves students working together in groups to exchange ideas, clarify important concepts, and solve problems. In connection, Augmented reality enables the interaction between digital objects or models within the social learning environment, allowing students to develop practical skills. Moreover, creating immersive problem-solving scenarios that emphasize the significance of teamwork might be beneficial. The pupils have the option to collaborate to tackle the existing issues, either engaging in virtual escape games or participating in group simulations.

To make the application of augmented reality in collaborative learning strategies effective, it is important to target the greatest contribution. With this, the scientific literacy of the students will be a great target to improve.

Scientific literacy is exhibited by employing scientific knowledge to identify issues, acquire new knowledge, portray scientific phenomena, and provide logical explanations of events based on facts gathered from the environment. Scientific literacy is the ability to understand, assess, and apply scientific information and ideas in everyday situations (Roberts D., 2013). Teachers are the key when it comes to developing scientific literacy among students. Teachers have the excellent opportunity to build a strong and quality foundation of science in students who in the future will carry out great tasks for society and the world.

According to Fives, et al. (2015), being involved in doing science is a precondition for scientific literacy. The introduction of augmented reality suits the learning-by-doing experiences as it takes students through investigations, experiments, and hands-on activities, which allows them to capture, document, evaluate, and make meaning from their own. Moreover, it is one of the instruments that contribute to developing their understanding of science as well as the capacity to engage in science-related conversation, explain natural events, and propose ways to answer questions scientifically. Scientific literacy and technology are two contingent entities. Scientific literacy creates a base for understanding and utilizing technology, while technology promotes the spread of scientific knowledge, thus making us scientifically literate. They are cohesive units that induce innovation, progress, and development of different societies.

OBJECTIVES OF THE STUDY

The objective of this study was to assess the effectiveness of utilizing augmented reality in collaborative learning strategies to enhance students' scientific literacy. Precisely, it aimed to assess the pre-test and post-test scores of the two groups of respondents exposed to the application of augmented reality in collaborative learning strategies in terms of context, knowledge, competence, and attitude. In addition, it aimed to evaluate the significant difference

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between the pre-test and post-test scores of the two groups of respondents exposed to the application of augmented reality in collaborative learning strategies.

METHODOLOGY

Research Design

The quasi-experimental study design was utilized in this study. The researcher utilized a pretest-posttest research design in which the researcher gave participants the same evaluation measures before and after treatment to evaluate if any changes could be linked to the treatment. In the study, the researcher used a test of scientific literacy to be administered before and after utilizing augmented reality in collaborative learning strategies. This research design was utilized to collect the necessary data and information and all gathered data were analysed to arrive at concrete and reliable results.

Respondents of the Study

The respondents of the study were composed of two intact groups, each with forty (40) Grade 9 students for School year 2023-2024 in Sta. Anastacia-San Rafael National High School, one of the public schools in the City of Sto. Tomas, Batangas to participate in the process. Quasi-experimental designs do not assign respondents to groups at random. Cluster sampling was utilized as they have been seen to be a beneficial option in such instances. Furthermore, the researcher applied a snowball strategy that incorporated augmented reality in one group while Project-based collaborative learning was implemented in the other group and see if there was a substantial relationship to the scientific literacy of the students.

Data Gathering Instrument

Research instruments used in the study are lesson plans and researcher-made tests. These instruments were used in the collection of data to test the validity and reliability of the findings of the research being conducted.

The researcher designed a lesson plan that served as a teaching guide while administering the two strategies to the learners. The researcher utilized Assemble Studio as a primary application to incorporate augmented reality in collaborative learning strategies. Meanwhile, researcher-made test served as a pre-test and post-test to assess the prior knowledge of the students regarding the topics and evaluate the effectiveness of the strategies utilized. It was composed of 40 questions with proportionate allocation of test items whereas the researcher assured that the test questions are aligned to the learning competency, and it can measure the scientific literacy of the students.

Data Gathering Procedure

Pre-Implementation. Before integrating augmented reality into collaborative learning strategies, the researcher sought validation from experts in the field for the instruments. The recommendations were integrated into the finalization of the research tool when it was retrieved. The prescribed protocol was adhered to. The researcher composed a formal letter addressed to the school principal, seeking clearance to carry out the study at Sta. Anastacia-San Rafael National High School. The researcher also apprised the respondents of the research methodology. They possessed a complete understanding of the research and its importance to the school, instructors, parents, community, and particularly to their fellow learners.

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Implementation. With all the suggestions and recommendations from the experts incorporated, the researcher administered a pre-test to the student respondents. After gathering the data from the pre-test, the researcher began the days of course execution with the integration of snowball collaborative learning strategy with augmented reality in one group and project-based collaborative learning strategy with augmented reality in the other group. Full supervision of the researcher was maximized in the implementation of the two distinct approaches.

Post-Implementation. After the implementation of augmented reality in collaborative learning strategies, the researcher conducted a post-test on the two student groups to see whether there was a notable enhancement in the students' scientific literacy. Upon gathering all the data, the researcher systematically organized and calculated the test results. The researcher thoroughly examined all the collected data to derive the most optimal outcome of the investigation. Therefore, the secrecy of the exam results and data is guaranteed due to the significance of the identities involved.

Statistical Treatment of Data

The frequency distribution and percentage count were used in the study to determine the result of the test scores of the respondents before and after the implementation of augmented reality in collaborative learning strategies, the gathered and tallied data were interpreted using this statistical treatment.

The t-test was used to determine whether there was a significant difference between the pre and post-test scores of the two groups of respondents exposed to the application of augmented reality in collaborative learning strategies.

RESULTS AND DISCUSSION

Table 1. Pre-test Scores in Scientific Literacy Test of the Respondents Exposed to Augmented Reality in Collaborative Learning Strategies as to Context.

Scores	Snowball Strategy		Project-based Strategy		Verbal Interpretation
	f	%	F	%	
9 to 10	0	0	0	0	Advanced
7 to 8	1	2.5	3	7.5	Proficient
5 to 6	12	30	17	42.5	Approaching Proficiency
3 to 4	26	65	17	42.5	Developing
0 to 2	1	2.5	3	7.5	Beginning
TOTAL	40	100	40	100	

Table 1 illustrates the pre-test scores in the scientific literacy test of the two groups of respondents exposed to augmented reality in collaborative learning strategies as to context. It is shown that the majority of the respondents exposed to snowball strategy are at the developing level, as evidenced by the fact that 26 out of 40 (65%) attained scores of 3-4. It implies that most of the students in snowball strategy have limited capacity in terms of identifying real-world scenarios involving Science. On the other hand, there are no students in the

snowball strategy who attained the advanced level. It means that before teaching, there are no students who are fully capable of finding connections between real-life situations and science. Moreover, it is also shown that 17 out of 40 respondents (42.5%) attained scores of 3-4, developing level, and 5-6, approaching proficiency level respectively. It indicates that most of the students have limited ability to identify real-world scientific circumstances. On the other hand, there are no students exposed to project-based strategy is considered advanced. It simply means that no students can be able to fully apply science concepts in everyday life.

Context skills offer the reasoning behind learning. This is significant because it provides a solid foundation for explaining the concepts to students in a way that makes sense as it provides practical application. Since students have limited knowledge regarding the topic, the result of the pre-test reveals that students are not yet able to fully connect scientific concepts with the actual world.

According to Aliyyah, et al. (2020), to enhance students' ability to recognize life situations in science, teachers must expose students to contextualized learning. This involves the incorporation of real-world examples, case studies, projects, and problem-solving activities in science teaching. As a result, students are more likely to remember and apply their information and skills outside of the classroom and they also recognize the importance of what they are learning.

Table 2. Pre-test Scores in Scientific Literacy Test of the Respondents Exposed to Augmented Reality in Collaborative Learning Strategies as to Knowledge.

Scores	Snowball Strategy		Project-based Strategy		Verbal Interpretation
	f	%	f	%	
9 to 10	1	2.5	0	0	Advanced
7 to 8	12	30	12	30	Proficient
5 to 6	21	52.5	26	65	Approaching Proficiency
3 to 4	6	15	2	5	Developing
0 to 2	0	0	0	0	Beginning
TOTAL	40	100	40	100	

Table 2 illustrates the pre-test scores in the scientific literacy test of the two groups of respondents exposed to augmented reality in collaborative learning strategies as to knowledge. It is shown that most of the respondents exposed to snowball strategy are at the approaching proficiency level, 21 out of 40 (52.5%) attained scores of 5-6. It means that most of the respondents in snowball strategy have a partial understanding of major facts, concepts, and theories in science. It is also indicated in the table that the majority of the respondents in project-based strategy are at the approaching proficiency level. There 26 out of 40 (65%) respondents attained scores of 5-6. It implies that most of the students possess limited cognitive capacity when it comes to comprehending and processing information related to scientific principles, theories, and empirical data. On the other hand, none of the students have attained the advanced level in project-based strategy. This suggests that no students can completely comprehend the fundamental ideas, concepts, and principles of science.

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Understanding scientific concepts and ideas fuels innovation and drives progress in society. By understanding foundational concepts and facts in science, people can contribute to the development of new technologies, processes, and ideas that address complex challenges and improve quality of life. According to Fisher et al. (2019), Hands-on experiments can enhance students' ability to understand scientific concepts as they engage the students in active participation in experiments that demonstrate key scientific principles. A deeper understanding of science is strengthened when these ideas are applied.

Table 3. Pre-test Scores in Scientific Literacy Test of the Respondents Exposed to Augmented Reality in Collaborative Learning Strategies as to Competence.

Scores	Snowball Strategy		Project-based Strategy		Verbal Interpretation
	f	%	F	%	
9 to 10	2	5	1	2.5	Advanced
7 to 8	16	40	13	32.5	Proficient
5 to 6	19	47.5	20	50	Approaching Proficiency
3 to 4	3	7.5	6	15	Developing
0 to 2	0	0	0	0	Beginning
TOTAL	40	100	40	100	

Table 3 illustrates the pre-test scores in the scientific literacy test of the two groups of respondents exposed to augmented reality in collaborative learning strategies as to competence. The majority of the respondents in the snowball strategy are at the approaching proficiency level. There 19 out of 40 (47.5%) achieved the scores of 5-6. This means that a significant portion of students lack the necessary skills to explain scientific phenomena comprehensively. Meanwhile, there are two out of 40 (5%) in snowball strategy are at an advanced level as they attained scores of 9-10. It means that only a few students can be able to design, evaluate, and interpret data and evidence scientifically. On the other hand, there are 20 out of 40 (50%) in the project-based strategy are at the approaching proficiency level because they attained the scores of 5-6. This implies that most of the students don't have enough skills to articulate and offer convincing arguments in different circumstances using science. Likewise, it is also shown in the table that only one student in the project-based strategy attained scores of 9-10 and considered advanced. It means that before the instruction, only one student can be able to evaluate and explain observed events or processes from a scientific point of view using empirical evidence, logical reasoning, and established scientific theories.

Competence skills involve explaining and giving reasons for different situations from a scientific point of view. Explaining and reasoning can help students think critically about what they are learning. It involves assessing data, exploring the points of view of others, and drawing logical links between scientific concepts which helps them improve their critical thinking skills. Since there are no instructions before giving the assessment, during the pre-test, students are not yet fully capable of explaining and expressing their ideas in different situations scientifically.

Rashid et al. (2016) suggest that employing peer teaching and learning can help students develop their competence skills as it engages the learners in collaborative discussions and challenges them to reflect carefully on the

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underlying scientific theories that underpin natural events. It also encouraged the learners to defend their responses and provide evidence for their arguments leading them to develop their competence skills as they impart knowledge to their classmates and benefit from one another's experiences.

Table 4. Pre-test Scores in Scientific Literacy Test of the Respondents Exposed to Augmented Reality in Collaborative Learning Strategies as to Attitude

Scores	Snowball Strategy		Project-based Strategy		Verbal Interpretation
	F	%	F	%	
9 to 10	0	0	2	5	Advanced
7 to 8	12	30	9	22.5	Proficient
5 to 6	21	52.5	17	42.5	Approaching Proficiency
3 to 4	5	12.5	10	25	Developing
0 to 2	2	5	2	5	Beginning
TOTAL	40	100	40	100	

Table 4 illustrates the pre-test scores in the scientific literacy test of the two groups of respondents exposed to augmented reality in collaborative learning strategies as to attitude. It is shown that a large portion of the students in the snowball strategy achieved approaching proficiency level. There 21 out of 40 (52.5%) attained scores of 5-6. This means that before teaching, most of the students are not fully motivated to act responsibly towards the environment and natural resources, and they show little interest in taking part in scientific investigations. Furthermore, it is also shown in the table that no students in snowball strategy attained the advanced level. It indicates that before the instruction, not a single student was driven to develop a sustainable environment or was genuinely interested in taking part in science-related activities. In project-based strategy, there are 17 out of 40 (42.5%) are at the approaching proficiency level as they attained scores of 5-6. It simply implies that before the instruction, the majority of the students in project-based strategy have limited skills and motivation to support the sustainable management of natural resources, which will benefit both the present and future generations. Additionally, it is also shown in the table that only 2 out of 40 (5%) respondents are considered advanced as they attained scores of 9-10. This means that only a small percentage of students are fully motivated to take care of the environment and natural resources.

An interest in science can have a substantial impact on one's drive to act properly toward natural resources and environmental issues. Those who are interested in science frequently participate in educational outreach to increase awareness about environmental challenges and advocate sustainable lifestyles. Likewise, individuals with a strong interest in science are frequently at the forefront of developing solutions to reduce environmental impact and enhance resource efficiency. Since no instruction was provided before the assessment, students are not yet fully motivated to take proactive steps to conserve and preserve the environment and natural resources.

Goldman et al. (2018) stated that students need to understand how environmental challenges impact their everyday lives, future careers, and global society to develop a sense of appreciation and responsibility towards the

environment. Students are more likely to be inspired to take action when they can relate the lesson to their interests and goals.

Table 5. Post-test Scores in Scientific Literacy Test of the Respondents Exposed to Augmented Reality in Collaborative Learning Strategies as to Context

Scores	Snowball Strategy		Project-based Strategy		Verbal Interpretation
	f	%	f	%	
9 to 10	13	32.5	35	87.5	Advanced
7 to 8	24	60	5	12.5	Proficient
5 to 6	3	7.5	0	0	Approaching Proficiency
3 to 4	0	0	0	0	Developing
0 to 2	0	0	0	0	Beginning
TOTAL	40	100	40	100	

Table 5 illustrates the post-test scores in the scientific literacy test of the respondents exposed to augmented reality in collaborative learning strategies as to context. It is stated in the table that there are 24 out of 40 (60%) respondents exposed to snowball strategy attained scores of 7-8 and considered proficient.

This indicates that most students significantly improved in identifying real-world scenarios involving science after using augmented reality and snowball strategy in the instruction.

On the other hand, no students in snowball strategy are at the developing and beginning level. This implies that none of the students have difficulty in terms of finding connections between real-life situations and science. In project-based strategy, there are 35 out of 40 (87.5%) are at the advanced level as they attained the scores of 9-10. It simply means that a large number of respondents are fully capable of applying science concepts in everyday life.

It is also shown in the table that no student is in the beginning and developing level. It indicates that not a single student is struggling in terms of identifying real-world scientific situations because of the incorporation of augmented reality and project-based strategy in the teaching-learning process.

Context skills of the students can be developed by the use of augmented reality. According to Aggarwal R. and Singhal A. (2019), augmented reality can create a lifelike experience as it provides an immersive and interactive experience that feels natural and realistic.

Moreover, augmented reality can recreate real-world surroundings and historical sites, allowing for virtual field trips to places that would otherwise be unavailable or expensive to visit. Students can learn about past civilizations, visit landmarks, and even go to outer space from the comfort of their classroom.

These features of augmented reality can help students enhance their ability to recognize life students in science.

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Table 6. Post-test Scores in Scientific Literacy Test of the Respondents Exposed to Augmented Reality in Collaborative Learning Strategies as to Knowledge

Scores	Snowball Strategy		Project-based Strategy		Verbal Interpretation
	f	%	f	%	
9 to 10	13	32.5	35	87.5	Advanced
7 to 8	24	60	5	12.5	Proficient
5 to 6	3	7.5	0	0	Approaching Proficiency
3 to 4	0	0	0	0	Developing
0 to 2	0	0	0	0	Beginning
TOTAL	40	100	40	100	

Table 6 illustrates the post-test scores in the scientific literacy test of the respondents exposed to augmented reality in collaborative learning strategies knowledge.

It is shown that the majority of the students are proficient in snowball strategy. 24 out of 40 (60%) attained the scores of 7-8. It means that most of the respondents in snowball strategy can understand the major facts, concepts, and theories in science after the instruction. Furthermore, it is also shown in the table that no student is at the developing and beginning levels. This means that no student is having a hard time when it comes to comprehending and processing information related to scientific principles, theories, and empirical data after applying augmented reality and snowball strategy in the instruction. On the other hand, there are 35 out of 40 (87.5%) exposed to project-based strategy attained a score of 9-10 and considered advanced and none of the students are at the approaching proficiency, developing, and beginning level. This indicates that the majority of the respondents can completely comprehend the fundamental ideas, concepts, and principles of science after incorporating augmented reality and project-based strategy in the instruction. The knowledge of the students has significantly improved when the teachers utilized augmented reality in the instruction.

According to Crandall P. G. et al. (2015), students can visualize abstract and difficult scientific concepts with the help of augmented reality. By using augmented reality (AR), students can gain a deeper understanding of different concepts like geological formations, celestial occurrences, and molecular structures by seeing them in three dimensions. They also added that the use of augmented reality produces an engaging and dynamic learning environment that grabs students' interest and engagement. Teachers can make learning more fun and can be able to inspire students to explore more of science by introducing gamification aspects in augmented reality.

Table 7. Post-test Scores in Scientific Literacy Test of the Respondents Exposed to Augmented Reality in Collaborative Learning Strategies as to Competence

Scores	Snowball Strategy		Project-based Strategy		Verbal Interpretation
	f	%	f	%	
9 to 10	27	67.5	26	65	Advanced
7 to 8	13	32.5	14	35	Proficient

5 to 6	0	0	0	0	Approaching Proficiency
3 to 4	0	0	0	0	Developing
0 to 2	0	0	0	0	Beginning
TOTAL	40	100	40	100	

Table 7 illustrates the post-test scores in the scientific literacy test of the respondents exposed to augmented reality in collaborative learning strategies as to competence. It is shown in the table that after the instruction, there are 27 (67.5%) respondents exposed to the snowball strategy achieved the advanced level as they attained a score of 9-10. This means that more than half of the respondents can explain scientific phenomena comprehensively. On the other hand, there are no students who fall into the approaching proficiency, development, and beginning level after the instruction. This indicates that not a single student is incapable of designing, assessing, and interpreting data and evidence scientifically.

In the project-based strategy, it is also shown in the table that the majority of the respondents are at the advanced level. There 26 out of 40 (65%) attained the scores of 9-10. This simply implies that the application of augmented reality along with a project-based strategy can make most of the students capable of offering convincing arguments in different circumstances using science. On the other hand, no student is approaching proficiency, development, and beginning level. It signifies that none of the pupils lack the necessary skills to evaluate and explain observed events or processes from a scientific perspective. Based on the result of the post-test, the application of augmented reality in the classroom has significantly improved students' capacity to express their ideas scientifically.

Shawaludin et al. (2019) stated that Augmented reality allows numerous students to engage with virtual models at once, which promotes collaborative learning experiences. Students with different origins, knowledge bases, and viewpoints come together through collaboration. Students' capacity to express their thoughts clearly in the context of science can improve when they collaborate and exchange ideas with one another. Aside from that, the diversity of the learners allows many facets of a phenomenon to be explored and discussed in greater detail. They can have a deeper understanding of science because various students may observe different elements of an event or have distinct insights into its underlying scientific concepts.

Table 8. Post-test Scores in Scientific Literacy Test of the Respondents Exposed to Augmented Reality in Collaborative Learning Strategies as to Attitude

Scores	**Snowball Strategy**		**Project-based Strategy**		**Verbal Interpretation**
	f	%	f	%	
9 to 10	18	45	21	52.5	Advanced
7 to 8	20	50	17	42.5	Proficient
5 to 6	2	5	2	5	Approaching Proficiency
3 to 4	0	0	0	0	Developing
0 to 2	0	0	0	0	Beginning
TOTAL	40	100	40	100	

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Table 8 illustrates the post-test scores in the scientific literacy test of the respondents exposed to augmented reality in collaborative learning strategies as to attitude.

Based on the table, 20 out of 40 (or 50%) of those who were exposed to the snowball strategy were deemed proficient after receiving scores of 7-8. This suggests that the incorporation of augmented reality and snowball strategy can help students to become fully motivated in acting responsibly towards the environment and natural resources, and they are interested in taking part in scientific investigations. It is also shown that no student in snowball strategy is in the beginning and developing level. It means that none of the students show little interest in developing a sustainable environment after the instruction.

On the other hand, most of the students exposed to project-based strategy are at the advanced level. There 21 out of 40 (52.5%) attained scores of 9-10. This means that students are highly motivated to take proactive steps to conserve and preserve the environment and natural resources after using augmented reality and project-based strategies in the teaching-learning process. It is also shown in the table that no student is in the developing and beginning levels. This indicates that after the instruction and application of the strategy, not a single student shows minimum interest in taking good care of the environment and its natural resources.

A study by Anuar, et al. (2021) also concluded that the use of augmented reality as learning material can have a positive effect on students' motivation to act accordingly towards the environment. AR applications can provide interactive learning experiences that allow students to engage directly with environmental concepts. They can virtually explore ecosystems, witness environmental changes over time, or interact with virtual specimens. Thus, amplify their passion and sense of accountability in protecting and preserving the environment and natural resources for present and future generations.

Table 9. Significant Difference of Pre-Test Scores in Scientific Literacy Test of the Respondents Exposed to Augmented Reality in Collaborative Learning Strategies

Scientific Literacy	Snowball Strategy		Project-based strategy		T	Df	Sig.(2-tailed)	Verbal Interpretation
	Mean	SD	Mean	SD				
Context	4.25	1.03	4.58	1.32	C	78	0.223	Not significant
Knowledge	5.83	1.22	5.93	1.10	-0.386	78	0.700	Not significant
competence	6.40	1.39	6.20	1.36	0.649	78	0.518	Not significant
Attitude	5.70	1.49	5.35	1.81	0.946	78	0.347	Not significant
Overall	**22.18**	**2.36**	**22.05**	**2.77**	**0.217**	**78**	**0.829**	**Not significant**

Legend: If p-value Sig. (2-tailed) ≤.05, then it is statistically significant. If p-value Sig. (2-tailed) >.05, then it is NOT statistically significant.

Table 9 presents the test of difference on the pre-test scores in the scientific literacy test of the two groups of students exposed to augmented reality in collaborative learning strategies.

The data revealed that there is no significant difference in the pre-test scores of the respondents exposed to augmented reality in collaborative learning strategies in terms of all domains of scientific literacy. This means that the two groups of respondents have nearly the same level in terms of context, knowledge, competence, and attitude.

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Context is the ability of the learners to recognize life situations in science. Before instructions, both groups of students have limited capacity to recognize how scientific principles apply to real-world situations, consider the historical and cultural context of scientific discoveries, comprehend the ethical implications of scientific research, and acknowledge the connections between various scientific disciplines. This limited capacity of the students is inevitable since the material has not yet been covered. Students frequently have prior knowledge of life circumstances that involve science since science is inextricably linked to the world around us. Students begin to notice and interact with natural phenomena from a young age and these observations establish a foundation of experiential knowledge, which students bring to the classroom (Pietrocola & Gurgel, 2017).

Knowledge is described as understanding or awareness of facts, principles, theories, and conceptions about the natural world acquired using observation, experimentation, analysis, and interpretation. Students in both groups of respondents displayed the same level of understanding of scientific facts, concepts, and theories, but to a lesser extent because they were not yet exposed to any instruction.

As stated by Kepes et al. (2014), science is an accumulative field, meaning that learning new subjects usually requires prior knowledge. Students can comprehend scientific subjects to some degree even without explicit instruction, as they can utilize their prior knowledge from earlier years or courses to grasp more complex concepts, albeit to a lower degree.

Competence pertains to the learners' capacity to provide scientific explanations for phenomena. Both sets of students exhibit equivalent proficiency in articulating findings, rationalizing methodologies, and constructing evidence-based arguments in the field of science before their introduction to augmented reality in collaborative learning approaches. According to Hamel et.al (2015) Explanation-seeking rather than fact-seeking pedagogies have been shown to warrant deeper student understanding of science.

To develop better student comprehension skills, explanation-driven rather than fact-driven teaching practices have proven to be more effective. Based on the study, students who had the best written explanations on Knowledge Forum scored much higher on the post- activity interviews even when they had scored much lower than less active students in the pre-activity interviews.

Attitude refers to learners' interest to act accordingly towards the environment and natural resources. Before teaching, the two groups of respondents demonstrated the same degree of interest in science and stewardship toward the environment. Before the instruction, students do show not much interest in taking care of the environment. Some students cannot fully understand the importance of environmental conservation or the impact of their actions on the environment.

According to Barr and Gilg (2017), by raising public awareness and fostering environmental literacy through education, outreach, and communication efforts, more individuals will become highly motivated to act accordingly toward natural resources. Likewise, Empowering individuals with knowledge about environmental issues and solutions can inspire behavior change and encourage collective action.

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Table 10. Significant Difference of Post-Test Scores in Scientific Literacy Test of the Respondents Exposed to Augmented Reality in Collaborative Learning Strategies

Scientific Literacy	Snowball Strategy		Project-based strategy		T	df	Sig.(2-tailed)	Verbal Interpretation
	Mean	SD	Mean	SD				
Context	8.10	1.01	9.50	0.96	-6.360	78	0.000	Significant
Knowledge	8.55	0.71	9.70	0.52	-8.252	78	0.000	Significant
Competence	8.95	0.96	8.93	0.97	0.116	78	0.908	Not significant
Attitude	8.38	1.15	8.65	0.83	-1.226	78	0.224	Not significant
Overall	**33.98**	**1.80**	**36.78**	**1.80**	**-6.940**	**78**	**0.000**	**Significant**

Legend: If p-value Sig. (2-tailed) ≤.05, then it is statistically significant. If p-value Sig. (2-tailed) >.05, then it is NOT statistically significant.

Table 10 presents the test of difference on the post-test scores in the scientific literacy test of the two groups of respondents exposed to augmented reality in collaborative learning strategies.

The table above reveals that there is a significant difference in the post-test scores in the scientific literacy test of the two groups of respondents exposed to augmented reality in collaborative learning strategies as to context and knowledge. It means that one collaborative learning strategy outperforms the other in terms of enhancing the conceptual and contextual skills of the student. It is also presented as well that there is no significant difference in the post-test scores in the scientific literacy test of the two groups of respondents exposed to augmented reality in collaborative learning strategies as to competence and attitude. This implies that both methods are equally effective in enhancing students' competence and attitude towards science.

Context skills refer to the ability of learners to understand, interpret, and make use of scientific concepts to appropriately respond to the context of a situation or task. It is important to develop students having this skill because many problems arise in our environment that can be solved by applying scientific concepts. Although both groups of respondents learned, the project-based strategy is more effective in enhancing context skills among students than the snowball strategy. Project-based strategy often incorporates real-world challenges or scenarios in the teaching-learning process. Working on projects that are relevant to everyday life allows students to see the relevance of science principles and how they apply outside of the classroom.

The findings of the study are similar to Sarwi et al. (2021), a project-based strategy establishes a context for learning. Instead of simply studying abstract scientific concepts, students engage with them in a practical, real-world scenario, thus, improving their problem-solving skills. Knowledge is the ability of the students to understand major facts, concepts, and explanatory theories that form the basis of scientific knowledge. It is distinguished by its rigor, empirical foundation, and reliance on data obtained through observation, experimentation, and logical reasoning. Based on the result of the post-test, respondents from both groups learned, however, students from the project-based strategy demonstrated significant improvement in terms of understanding scientific concepts, facts, and theories. Project-based learning engages students in hands-on activities where they actively manipulate materials, conduct experiments, and solve problems. These hands-on activities deepen students' understanding of scientific concepts and enhance retention of scientific knowledge.

It is parallel to the study of Rumahlatu and Sangur (2019) that implementing a project-based strategy can help students enhance their concept acquisition, and knowledge retention in science. They added that when students learn by doing, they are more likely to remember what they have learned. The information gained by completing a project and meaningful learning is bound to be stored in long-term memory.

Table 11. Significant Difference of Pre-Test and Post-Test Scores in Scientific Literacy Test of the Respondents Exposed to Augmented Reality in Collaborative Learning Strategies

COLLABORATIVE LEARNING STRATEGIES	Pre-test		Post-test		T	Df	Sig.(2-tailed)	Verbal Interpretation
	Mean	SD	Mean	SD				
Snowball	22.18	2.36	33.98	1.80	43.574	39	.000	Significant
Project-based	22.05	2.77	36.78	1.80	36.639	39	.000	Significant

Legend: If p-value Sig. (2-tailed) ≤.05, then it is statistically significant. If p-value Sig. (2-tailed) >.05, then it is NOT statistically significant.

Table 11 presents the test of difference on the pre-test and post-test scores in the scientific literacy test of the two groups of respondents exposed to augmented reality in collaborative learning strategies.

The table reveals that there is a significant difference between the pre-test and post-test scores of the respondents as they are exposed to augmented reality in collaborative learning strategies. The result shows that the students improve their scientific literacy by incorporating augmented reality into both snowball and project-based strategies.

Different collaborative learning strategies are proven to be effective in developing the scientific literacy of the students. Collaboration allows learners to participate in conversations, debates, and joint problem-solving activities, which can lead to a better comprehension of scientific concepts. It allows learners to share their opinions and ideas which can lead to the retention of knowledge through reinforcement and social validation of information. Moreover, collaborative learning entails collaborating with others from various backgrounds and viewpoints. This diversity can expose learners to new perspectives and approaches to scientific research, allowing them to get a more nuanced grasp of complex scientific issues. Likewise, it involves applying scientific knowledge to real-world challenges or situations. Thus, working together to address authentic problems allows students to see the practical application of scientific concepts and gain a better understanding of science's role in society.

Combining collaborative learning strategies and augmented reality can have a significant impact on the students and it is effective in enhancing the scientific literacy of the students. It improves student engagement by creating immersive and engaging experiences that augmented reality can offer. When students have the opportunity to manipulate AR, they can explore concepts in a hands-on manner, which can lead to a better understanding of scientific concepts and improve students' retention of knowledge in science. In addition, the opportunity to share their expertise in using technology as they use AR can empower students and boost their self-confidence and efficacy. Using augmented reality in collaborative learning strategies allows educators to create dynamic and interactive learning environments that cater to various learning styles and interests, empowering students to take ownership of their learning journey.

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According to the study by Ahmed et al. (2021), students' scientific literacy improved significantly as they incorporated augmented reality in the instruction. However, it was shown that students in different classes got a different level of improvement in scientific literacy. Even though the students have completed the same learning process, they have diverse approaches to understanding and transforming knowledge in science.

Perez-Lopez and Contero (2013) found out that augmented reality-based teaching and learning are more effective than conventional approaches in terms of knowledge retention. This is because augmented reality activates multiple sensory modalities, including touch, sight, and sound. As a result, learners get actively involved in the learning process. Furthermore, 3D models can be manipulated and viewed from all angles. Augmented reality-based teaching and learning materials give auditory explanations, so the learners do not need to read all of the text. Manipulating models to the desired viewpoint at any time allows the learners to have complete control over their learning experience.

CONCLUSION AND RECOMMENDATION

Since the study found that there is a significant difference between the post-test scores of the two groups of respondents in context and knowledge, therefore the researcher recommends that teachers utilize a project-based strategy in developing context and knowledge domains of scientific literacy. It was found in the study that there is no significant difference in the post-test scores in the scientific literacy test of the two groups of respondents in competence and attitude. Therefore, the researcher recommends that both project-based and snowball strategies be utilized as it is equally effective in enhancing students' competence and attitude toward science. It was found in the study that there is a significant difference in the pre-test and post-test scores in the scientific literacy test of the two groups of respondents, Therefore, the researcher suggests that teachers may consider incorporating augmented reality to support collaborative learning strategies applied in the classroom. Future researchers may consider exploring different strategies that can be supported by augmented reality to enhance scientific literacy among students.

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