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Improving Grade 8 Students' Academic Performance and Attitude in Teaching Science through Augmented Reality

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ABSTRACT

Strategic Intervention Material for Teaching Augmented Reality (SIMaTAR) is a collection of teaching and learning materials in Science which uses augmented reality technology to greatly improve learning experience through digital immersion in different 3D and 4D worlds and is under the innovative approaches in science education project of DOST-SEI. This study aimed to assess the effectiveness of using SIMaTAR mobile application as a tool on improving the Grade 8 students' academic performance, motivation, and attitude towards learning science as well as the teachers' assessment upon using the application. Results showed that all indicators on the teachers and students' assessment on SIMaTAR mobile augmented reality application were rated as strongly agree. All indicators of students' attitude towards science showed improvement after implementing the AR application in science teaching. Further, the scores of the student participants in pre-test and post-test were remarkably increased after using the application. As for the challenges, results revealed that students do not have the gadgets to use and they lack the knowledge on how to manipulate the application. Through data analysis using paired samples t-test, it is concluded that the integration of SIMaTAR in teaching science increases the engagement and interest of the students in learning the subject and the application of mobile augmented reality could substantially improve the teaching and learning process.

INTRODUCTION

Augmented reality (AR) is the projection of virtual reality such as images, texts, videos, and sounds, on a screen to enhance the visual experience. This implies overlapping virtual information on digital devices to promote real-world experiences (Lo *et al.*, 2021). Augmented Reality is a technology that augments (combines) the real world with computer-generated virtual objects that appear to coexist in the same space as the real world. The computer-generated virtual scene or ambience is intended to improve the user's sensory perception of the world in which they are viewing or interacting (Ersozlu *et al.*, 2019). Today, a lot of people have started to utilize these technical tools more and more in their daily lives as a result of the growth of mobile and smart devices, a wide range of products, and the widespread usage of the internet. Therefore, people who are raised in this technological age will inevitably employ these devices in their schooling. The efficiency of Augmented Reality (AR) technology in the learning-teaching process is being debated as a result of technological advancements. It has become widely used in various fields. Although there were early issues with technical issues, hardware limitations, and cost of use, AR applications have developed concurrently with technological advancements, and their usability has increased (Talan, 2021).

Currently, there are three ways in which augmented reality applications work to gather information on a location and superimpose images that follow the landscape. The first and most reliable option to render 3D images into space is through the use of SLAM or Simultaneous Localization Mapping. These scans and maps out the geometry of the environment to effectively and convincingly overlay virtual elements onto the observable topography. Secondly, augmented reality applications may also be Location Based which relies heavily on GPS information accompanied by the digital compass of the device, gyroscope, and the accelerometer as well. This is used to identify where the device is on earth and superimpose images or text boxes onto notable locations. Lastly, AR applications may also be Recognition Based. Recognition Based AR apps, uses the camera to identify visual markers such as QR codes or Natural Free Tracking markers (NFT). This type of AR possesses multiple merits in education as it pegs the image upon the marker allowing it to remain steady as long as the camera of the device is able to read it properly. This allows the user to observe the corresponding 3D rendered image in various angles (Castro & Virata, 2019). These days, newly developed technologies such as AR are still trying to find a home inside the classroom (Nacharit & Srisawasdi, 2015). AR has been utilized to address gaps in different disciplines such as science which has been plagued with several challenges.

The convergence of globalization, ICT, and the information explosion, according to Malik (2018), has sparked profound changes in contemporary society that have put every facet of our way of life to the test. To deal with these rapid changes, we must train our employees in a variety of electrical technologies that are unique to the digital era. A fresh approach to the delivery of education

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is necessary to prepare citizens with a global perspective, cross-cultural awareness, the ability to collaborate in multicultural contexts on group projects, and the capacity to think critically and creatively. His study makes the case that the way education is provided to the "digital natives" of today and tomorrow must undergo a fundamental transition, especially in developing nations. According to the theory that a nation's strength depends on how well its residents are educated, it is essential for a nation to provide calibrated education in order to produce citizens who are capable of competing on a global scale. Additionally, Dunwill (2016) asserts that the development of technologies opens up countless opportunities for education. As a result, it will continue to change how teachers educate and how students learn in general. Other educational institutions from other nations throughout the globe have also begun to accept these adjustments. When compared to using a traditional learning approach, AR improves students' academic performance during the learning process (Ozdemir *et al*., 2018). However, many studies paid less attention to how technology affects social relationships or its social-psychological components and more attention to the technical details, effectiveness of various systems, usability, and design (Elliot and Mikulas , 2011).

Challenges in science education confront several countries across the world especially during this era of the fourth industrial revolution where technology is rife (Sadera *et al*., 2020). In the Philippine context, the use of educational technology is highly encouraged among teachers. This is required under the Philippine Professional Standard for Teachers or PPST. Specifically, the use of such technology is stipulated in Strand 1.3 or Positive use of ICT under Domain 1: Content Knowledge and Pedagogy, and Strand 4.5 or Teaching and learning resources including ICT under Domain 4: Curriculum and Planning in the PPST (DepEd Order 42, s. 2017). Cognizant of this, Science teachers in the Philippines have employed AR in teaching science. Castro & Virata (2019), delineated that AR not only improves motivation but also triggers more student-student and teacher-student interaction. It also increased students' learning attitude towards the subject specifically in terms of their appreciation for science, their perception of its relation to real life and of their meaning-making processes.

The same finding is also confirmed in the study of Santos (2019) which exposed that AR mobile applications can increase the learning interest and motivation of students that eventually improve performance of students. He concluded that utilization of a mobile augmented reality could substantially enhance teaching and learning process. In the Philippines, K+12 curricula already include IT education software for teaching students how to utilize computers. The use of hardware and software technology to establish subjects and subject areas. Numerous studies have found positive implications of augmented reality applications on student motivation, academic progress collaboration, dialogue, learning mindsets, and fun in secondary, tertiary, and post-secondary education.

Several studies have also proven the effectiveness of augmented reality (AR) as instructional material in science teaching and learning (Tsihouridis *et al*., 2020). Pirker & Lesjak (2017) disclosed in his study that AR provides students with excellent interactive and practical experience with positive learning outcomes. More so, in a study Craciun (2017) and Akcayir and Akcayir (2016) conducted, they revealed how AR enhances students' practical and cognitive skills and how it offers a creative approach to education. Additionally, AR also helps to facilitate the implementation of difficult experiments (Strzys *et al*., 2018) and can be used effectively to teach science-based information (Huang *et al*., 2019). Findings of the research of Tibola *et al*. (2019) also showed that the use of AR in science teaches highly satisfied students and it helps in building a positive attitude of students towards the subject.

A study conducted by Eldokhny and Drwish (2021) investigated the effectiveness of augmented reality in online distance learning at the time of the COVID-19 pandemic. Their study was carried out in an instructional software authoring tools course for instructional technology department students to develop academic achievement and instructional software design skills. The findings of their study showed that augmented reality was more effective than virtual classrooms without augmented reality in enhancing academic achievement and the development of skills in online distance learning. In general, pandemic periods can be effectively learned through online distance learning using augmented reality or one of its (fixed, animated) patterns. Additionally, they found out that location-aware or vision-based augmented reality may offer a lot of promise for online distance learning during the epidemic. In order to satisfy the demand for 21st-century abilities, teachers must be ready to use all augmented reality patterns in traditional online remote learning or during pandemics. In order to effectively study online distance learning during pandemic periods, more research must be done utilizing augmented reality with a different sample and varied information. In general, augmented reality or one of its (fixed, animated) patterns can be applied.

A similar study conducted by Ibáñez *et al*. (2020), aimed to determine the impact of an augmented reality (AR) application, NutricARd, on students' achievement and motivation. The NutricARd applications, which had undergone rigorous design and development research, were employed for the treatment group. There were 25 people in the control and experimental groups, respectively. The control group made advantage of the AR elements already included in the textbooks supplied by the Malaysian Ministry of Education. According to the study, there is a sizable achievement gap between the treatment and control groups. This study used semi-structured interviews, pre- and post-tests, and pre- and post-tests as research methodologies. The outcomes of the paired t-test revealed that there was also a significant

difference in the motivation of the students. The semi-structured interview demonstrated that AR-NutricARd has the potential and captivating features that entice kids to get interested in the study of science. The results of the study also revealed a significant connection between motivation and success. Higher motivation therefore suggests greater student accomplishment.

In the context of the present study, however, augmented reality mobile application has not been used in the teaching and learning of Grade 8 science in the locality specifically in provincial areas in the Philippines like where this study was conducted where science achievement of students is problematic owing to students' disinterest towards the subject. Thereby, it is the intent of this research to explore the effectiveness of SIMATAR as a teaching tool to improve the performance of the students under study as well as to boost their attitude towards the subject.

This study is very significant in foraging new and effective ways in the teaching and learning of science. By doing so, the researchers can hopefully help in leveraging the instructional processes in the Philippines through novel and innovative ways, and subsequently achieve the ultimate goal of providing quality science education to Filipino students

MATERIALS AND METHODS

This chapter presents the research design, research locale and participants, instrumentation, data gathering procedure and statistical tools that will be used in the pursuit of this study.

Research Design

The study used the mix method research design. The mixed methods research combines elements of quantitative research and qualitative research in order to answer research questions. The qualitative method established the impression of students in using SIMATAR Augmented Reality Mobile Application which consists of a strategic intervention material booklet and its mobile software application. The quantitative method, on the other hand, was used to measure the students' level of attitude towards science as well as student and teacher assessment on SIMATAR Mobile Application as a tool in learning science.

Research Locale and Participants

The study was conducted at Nasipit National High School-ANNEX located at Nasipit, Agusan del Norte. The school has a total of 946 student population and 25 teachers. It consists of 130 grade 8 students distributed in three sections. Out of these 130 students, only 20 were chosen as participants in this study using random sampling. Science teachers were also included as participants in this study. Out of 25 teachers, 10 are science teachers and were selected to participate in this study. The instrument was administered to the research population before and after the implementation of SIMATAR. The teacher observations and interviews were conducted to assess the student's attitude towards science.

Instrumentation

The researchers crafted an instrument to facilitate the collection of the necessary data. It was submitted to the adviser for content validation. The researchers used survey questionnaires and interviews as a significant data collection instrument to carry out this study. The data was collected from teachers and students.

The instrument of this study was partially adopted from the study of Santos (2021), titled Improving Performance and Attitude Towards Science Using Strategic Intervention Material in Teaching with Augmented Reality (SIMATAR) Mobile Application and the study of Shafeey *et al.* (2019) titled Challenges Analysis for Using Augmented Reality in Education: A Review.

A focus group discussion through the interview form was conducted which included questions regarding the students' views, ideas, feelings, and opinions about the program's execution and impact, as well as proposals for program improvements or revisions. The mobile augmented reality application was also evaluated by the teacher in terms of usability, visual appeal of graphics and photos, accuracy and up-to-dateness of information, and instructional value.

The mobile augmented reality application was evaluated by students in terms of content relevancy, visual appeal and design practicality, functionality, and motivation. Finally, the pre- and post-tests were used to assess students' performance before and after SIMaTAR adoption.

Data Gathering Procedure

To obtain the data needed in this study, the following steps were taken: Phase 1. Early Protocol to the Research Locale. A letter of permission was secured to conduct the study. The said letter was signed and granted by the School Principal. Phase 2. Administration of Pre-test. The researcher has conducted a 1 hour 20-item pre-test to the selected grade 8 participants simultaneously. Phase 3. Conduct of Classes using SIMATAR. After the administration of the pretest, the teacher-researcher then conducted classes to students using the strategic intervention material in teaching with augmented reality. Classes run for three weeks, and each class is taught for one hour. Phase 4. Administration of Post Test. A 1 hour 20-item post-test was conducted to the participants by the researchers simultaneously. Phase 5. Administration and Retrieval of the Survey Questionnaires. The researchers personally administered the survey to the student and teacher participants following the safety protocols to avoid contamination. A brief orientation was conducted with the school head, teachers and students. Phase 6. Data Analysis. The data gathered by the researchers were then analyzed.

Statistical Treatment of Data

The data gathered were processed using JASP, with descriptive statistics which includes the following: Percentages. Calculated by taking the frequency in the category divided by the total number of participants and

multiplying by 100%. Standard deviations. A measure of how dispersed the data is in relation to the mean. Low standard deviation means data are clustered around the mean, and high standard deviation indicates data are more spread out. Weighted Mean. Involves multiplying each data point in a set by a value which is determined by some characteristic of whatever contributed to the data point. Mean Difference. Measures the absolute difference between the mean value in two different groups. Paired samples t-test. Statistical procedure used to determine whether the mean difference between two sets of observations is zero. In a paired sample t-test, each subject or entity is measured twice, resulting in pairs of observations. To determine the student's level of attitude towards science, assessment on SIMATAR augmented reality mobile application and the challenges/ issues they have encountered in using the SIMATAR mobile augmented reality application, the interpretation of the mean scores on the questionnaire form will be based on the table below.

Table 1: Interpretation of the data gathered on Student's Level of Attitude Towards Science and Assessment on SIMaTAR Mobile Application

Rating	**Verbal Interpretation**
4.50- 5.00	Strongly Agree
3.50- 4.49	Agree
2.50-3.49	Moderately Agree
1.50-2.49	Disagree

RESULTS AND DISCUSSION

This chapter presents the results, the analysis and interpretation of data gathered from the answers to the questionnaires distributed to the field. The said data were presented in tabular and graphical form in accordance with the specific questions posited on the statement of the problem. Teachers' assessment in using SIMATAR mobile augmented reality application.

Table 2 shows the teacher's perceptions on SIMATAR mobile augmented reality application. It revealed that all of the indicators on teachers-assessment were rated as strongly agree.

Table 2: Teachers' assessment in using SIMATAR Application

Teacher Assessment on SIMATAR mobile application	**Weighted Mean**	**Verbal Interpretation**
Usability	4.80	Strongly Agree
Visual appeal	4.92	Strongly Agree
Accuracy and Up-to-Datedness of Information	4.83	Strongly Agree
Educational Value	4.90	Strongly Agree
Overall Mean	**4.90**	**Strongly Agree**

In terms of usability, the 10 teacher participants gave a high evaluation rating of 4.8 which signifies that the teachers strongly agree that SIMaTAR uses language that is appropriate to the intended users, provides clear instructions, is easy to use, and can be utilized in varied learning environments. Teachers also strongly agreed in terms of SIMATAR's visual appeal with a mean of 4.92. They found the application's graphics and pictures simple, recognizable, realistic with appropriate colors, attractive, engaging, interesting, clarify and supplement the text. Moreover, the raters also deemed the information presented on the application as accurate and very timely as evident on the 4.83 mean. For the educational value, it was given a rating of 4.9 which signifies that teachers strongly agreed that AR application helps the learners to visualize and understand the concept better, raises interest and degree of engagement, supports deeper understanding within the content domain, and makes learning more fun, exciting and interesting.

It is remarkable that all of the teacher participants strongly agreed about the integration of SIMaTAR in teaching science. They acknowledge the fact that the use of SIMaTAR will increase the engagement and interest of the students. Teachers are known for finding creative solutions when it comes to their students' lessons, especially for difficult subjects like Science and the biggest challenge was to find a way to make Science more fun for the learners. Alboruto (2020) identified Strategic Intervention Materials (SIMs) as an effective tool for connecting with large numbers of students. Five of Alboruto's SIMs have been transformed into Augmented Reality mobile applications through a partnership with the Department of Science and Technology Education Institute's SIMATAR project. In an interview with Summit Original Videos, Alboruto added that when using the mobile application, the learners were able to see 3D images and visually realistic representations of the lessons which enables her students to engage with their learning environment in new ways.

Supporting textbook materials with AR examples adds another dimension to the learning process in which it will become a hybrid of the traditional approach and innovative practical illustrations of complicated concepts. According to Johnston *et al.* (2019), AR technologies enable users to experience scientific phenomena that are not possible in the real world, such as certain chemical

reactions, making inaccessible subject matter available to students. The manipulation of virtual objects and observation of phenomena that are difficult to observe in the real world can be facilitated through AR. This type of learning experience can encourage thinking skills and increase conceptual understanding of phenomena that are either invisible or difficult to observe as well as correct any misconceptions. AR addresses learning difficulties that are often encountered with visualizing unobservable phenomena. This vouches for the study of Strzys *et al.* (2018) and Huang *et al.* (2019) that AR aids teachers in facilitating the implementation of difficult experiments and can be used effectively to teach science-based information. More so, Khan *et al.* (2019) which found AR to be beneficial in academic settings, as it allows a more efficient visualization of abstract concepts, which in turn, facilitates students' engagement and learning intentions. Furthermore, teachers also explained that all of the teachers must be trained properly in terms of implementing this SIMaTAR in their daily lessons. Some teachers also in other subjects wished that the DOST-SEI would also develop SIMaTAR modules and applications for other subjects like TLE, and Araling Panlipunan.

Students' assessment in using SIMATAR mobile augmented reality application

Table 3 shows the students' perceptions on SIMATAR mobile application in terms of relevance of content, visual appeal and design practicality, functionality and student's motivation. The table also revealed that all indicators of student-assessment were rated as strongly agree.

The students agreed strongly in terms of the content relevance of the SIMaTAR application. They think that the SIMaTAR showed scientific models and it represents the concepts as explained by the teacher. Also, they think that it can facilitate their understanding of science concepts easily and in a better way. According to Ophoff *et al.* (2019), relevance can be established through using language and examples that are familiar to the students. Familiarity involves providing examples that tie in with the student's experience and relate to the subject matter. Studies reported that a benefit of AR technology is the ability to provide immediate and relevant information and guidance

In terms of design, students strongly agreed that AR is visually appealing and attractive, uses legible text, uses appropriate colors for graphics and pictures and it has visible buttons and icons for correct manipulation and execution of commands. The functionality indicator showed results that students strongly agreed that AR application is user-friendly and it contains adequate task controls and 3D images which can be manipulated and viewed with ease. Moreover, students believe that AR motivates them and helps in understanding the lesson better and helps in improving grades.

Table 3: Students' assessment in using SIMATAR Application

Student Assessment on SIMATAR mobile application	Weighted Mean	Verbal Interpretation
Content Relevance	4.57	Strongly Agree
Visual Appeal and Design Practicality	4.50	Strongly Agree
Functionality	4.28	Strongly Agree
Student's Motivation	4.22	Strongly Agree
Overall Mean	**4.40**	**Strongly Agree**

Studies have shown that AR can have consistent positive impacts on student motivation. There are studies which prove that AR can specifically increase student motivation in science learning. According to Gopalan *et al.* (2017), the increased student motivation may be largely attributed to the elements of curiosity, fantasy, and control presented using AR technology, as student motivation may be directly influenced using an attractive or stimulating medium or learning material. In the study of Santos (2019), students showed eagerness to use AR technology applications in the future to learn other science lessons in the future such as weather, planets, microscopic organisms, cells, human body systems, other heavenly bodies and insects. The students expressed their excitement in using technology inside the classroom.

According to the study of Sharif (2018), learning through AR may promote student-teacher interaction and enhance students' satisfaction with the learning experience. It may also develop oral communication skills, social interaction skills and may encourage diversity understanding. The same finding was also established by Castro & Virata (2019) who delineated that AR not only improves motivation but also triggers more student-students and teacher-student interaction.

Attitude of students towards science before and after using the SIMaTAR mobile augmented reality application

Table 4 shows the effect of the mobile augmented reality application to student's attitude towards science. Looking at the first indicator of anxiety towards science, results revealed significant decline in students' anxiety level on science from disagree to strongly disagree (overall mean 2.30 to 1.85) after using SIMATAR. Students disagreed that working with science frustrates them. Even though student-participants claimed to disagree with having anxiety in science, their anxiety level decreased after utilizing SIMATAR.The students claimed that sometimes they find science difficult depending on the topic of the lesson but not to the point they feel frustrated over science and hate science. After they are introduced to the SIMaTAR application they think that it can help them in

understanding their lessons much better.

In the second indicator, student-respondents agreed that they had a positive enjoyment of science before the usage of SIMATAR. This positive attitude towards science continued to increase after the usage of the AR mobile application from moderately agree to agree (overall mean of 3.45 to 4.43). It is worthy to observe that students' perception of enjoyment of learning science, comfortability in taking science class and the real desire to learn science increased from agree to strongly agree. Furthermore, students seemed to realize the importance of reading science books after the usage of SIMATAR. A significant improvement was noted from moderately agree to agree (3.2 to 4.48) on reading science books ahead of class. After they used the SIMaTAR application it was clear that the attitude and perceptions of the students towards science changed in a positive way. Being introduced in the SIMaTAR application for the first time they find it amusing and new. In connection to that their attitudes from having a little anxiety in science to finding enjoyment while learning in science.

In the last indicator, student-participants agreed on the relevance of science in the society and in every life before the usage of SIMATAR. This positive outlook of the students about science continued to improve after the usage of the AR mobile application from agree (over all mean 3.84) to strongly agree (overall mean 4.5). The student participants strongly agreed that science is useful for solving the problems of everyday life because science has been a part of their lives and they claimed that the more they get to learn more about science they have a greater chance of having a good future.

Table 4: Students' attitude towards science before and after using SIMaTAR Mobile Application

Attitude Towards Science	Weighted Mean				Mean Difference
	Before	Verbal Interpretation	After	Verbal Interpretation	
Anxiety in Science	2.30	Disagree	1.85	Strongly Disagree	-0.44
Enjoyment in Science	3.452	Moderately Agree	4.33	Agree	0.88
Relevance in Science	3.84	Agree	4.50	Strongly Agree	0.65

According to the study of Lee (2012) AR has a better chance of improving educational situations than ever before, more productive, pleasant, and participatory. AR not only has the ability to engage a learner in previously unimaginable interactive ways, but it can also provide each individual with their own unique discovery path filled with rich content from computer-generated three-dimensional environments and models. Tibola *et al.* (2019) also attested that the use of AR in science teaches highly satisfied students and it helps in building a positive attitude of students towards the subject. Studies by Bos *et al.* (2019) reported that AR increased learners' focus, attention, and concentration. Bos examined a variety of educational technologies and increases in student focus and attention, and found that innovations, such as AR, when used appropriately, could enhance learning by increasing their focus and attentiveness.

The figure below shows the overall means of students' attitudes towards science before and after using the SIMaTAR application. It is observed that the overall

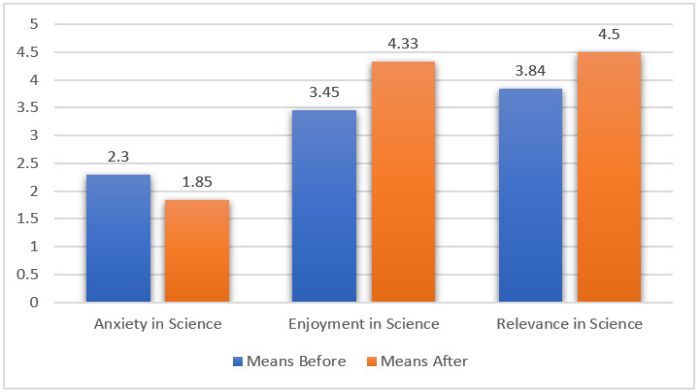

Figure 1: Overall means of students' attitudes towards science before and after using SIMaTAR application

means for their anxiety in science decreases after they used the SIMaTAR application (2.3 to 1.85) Also, the overall means of their enjoyment in science (3.45 to 4.33) and perceptions about the relevance of science in their daily lives increased (3.84 to 4.5)

In their systematic review of the research literature, Niu (2019) found that the key benefits of AR for learning included increased satisfaction, concentration, attention, and motivation. Increased satisfaction implies that students' experiences in the learning context rise to satisfactory levels, particularly during the learning process. Virata and Castro have the similar pronouncement that AR increased students' learning attitude towards the subject specifically in terms of their appreciation for science, their perception of its relation to real life and of their meaning-making processes.

Gain scores of the student participants in using SIMATAR mobile augmented reality application in their pre-test and post-test

Figure 2 shows the scores of the student participants in their Pre-Test and Post-Test. It is presented that all of the student participants remarkably had an increase of their scores after using the SIMaTAR mobile augmented reality application. The computed mean for the Pre-Test is 9.9 and in Post -Test a mean of 15.35. The mean difference between the means is 5.45. The increase of the scores of the students in their Post-Test indicates that they have improved after learning the lessons using the SIMaTAR application. This supports the claim of Tsihouridis *et al.* (2020) that augmented reality as an instructional material in science teaching and learning is effective in improving students' performance. Furthermore, Santos (2019) also disclosed that AR mobile application also improves the performance of students owing to the increase of learning interest and motivation of students.

A similar study conducted by Petrov and Atanasova

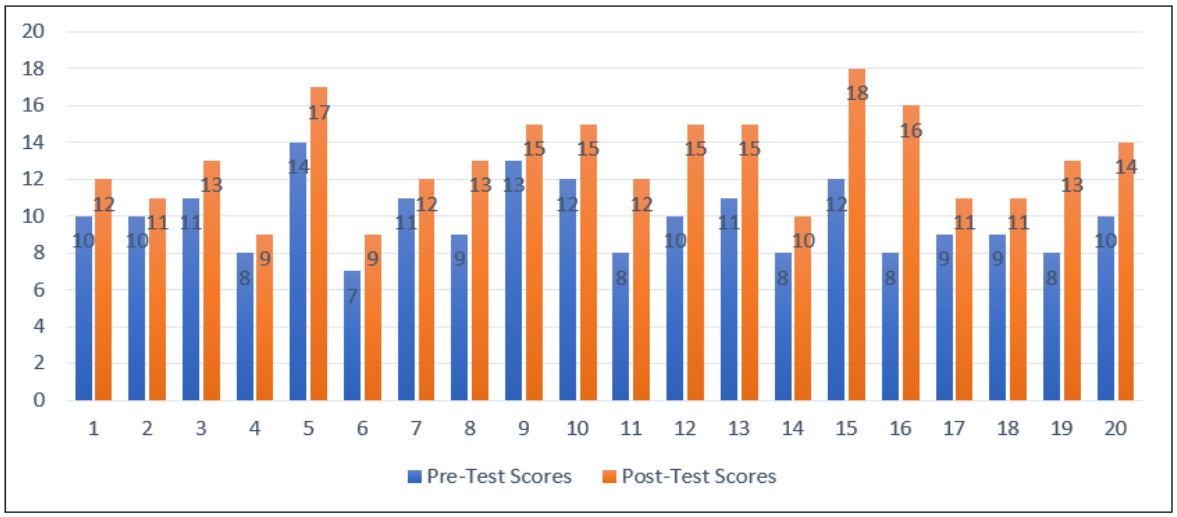

Figure 2: The gain scores of the student participants in their Pre-Test and Post-Test

(2020) aimed to explore the impact of an AR tool on students' learning performance. The study has shown a substantial improvement in students' understanding of the matter studied. Their research showed that AR technology, particularly when utilized in STEM education, enables students to explore, practice, and interact with STEM information without having to worry about pricey consumables or animal harm, for example. It offers chances for experimentation and failure recovery while working in a secure setting. The tools for virtual, augmented, and mixed reality generally offer this. Despite the programs and resources that are available, experience has proven that it is challenging for people to become more educated. Although it is obvious that people and technology must coexist, it is important to find the "golden ratio" between the two.

Chin *et al.* (2020) also conducted research in relation to augmented reality. They sought to evaluate the effectiveness of the proposed system. We conducted an experiment in a cultural heritage course at a Taiwanese university. Their experimental results showed that the AR-based mobile touring system significantly improved the students' memorizing dimension of learning achievement, as compared with a conventional mobile touring system (Berame *et al.* 2022). Additionally, the suggested system's favorable effects on students' actualized interests and task-based interests components yield a particularly beneficial outcome for outdoor activities. These experimental findings also point to the potential of augmented reality (AR) technology to boost students' interest in and academic performance in outdoor settings. In order to improve content recall performance and learning interest, we advise that AR virtual objects be created suitably when using a mobile touring system based on augmented reality in authentic learning activities.

In addition to examining the moderating impacts of learning styles using augmented reality, a study conducted by Lai and Chang (2021) also investigates the effects of AR apps on first graders' motivation for and performance in their English learning. Their respondents were split between an experimental group that learned using an augmented reality app, and a control group that learned using more conventional techniques. Numerous stochastics analyses were conducted. Based on the findings of their study they conclude that introducing augmented reality (AR) apps into first graders' English vocabulary acquisition can dramatically increase their motivation and proficiency.

A study that used augmented reality using the application pokemon go was conducted by Turel and Ozer Sanal (2018) that aimed to analyze the effect of 8 weeks of Pokémon GO on cognitive performance (memory, selective attention, concentration, mathematical calculation and linguistic reasoning) and emotional intelligence (well-being, self-control, emotionality and sociability) in Spanish adolescents between 12 and 15 years. They found out that Pokémon GO increases, in a playful way, the amount of daily exercise in adolescents, could positively affect their cognitive performance, and improve their social relationships.

Significant difference between the Pre-Test and Post-Test scores of the Grade 8 students before and after using SIMATAR mobile augmented reality application

Table 5 showed the significant difference between the pre- test and post-test mean scores of the students.

Since the p-value was 0.001 less than our significance level α=0.05, the researchers rejected the null hypothesis. The rejection of the null hypothesis suggests that there is a significant difference between the pre- test and post-test mean scores of the students before and after using the SIMaTAR Mobile application. As a result, we can conclude that the SIMATAR mobile augmented reality application has significant improvement on the mean score performance of the students.

Table 5: Significant Difference in the Pre and Post- Test

	Mean	SD	Mean Difference	Df	T-value at 0.05	Computed p-value	Interpretation
Pre-Test	9.900	1.889	5.45	19	-8.427	<0.001	Reject Null Hypothesis
Post-Test	15.350	2.277					

A study proposed by Chen (2019) was conducted to determine the "Effect of Mobile Augmented Reality on Learning Performance, Motivation, and Math Anxiety in a Math Course". Their study investigated whether mobile AR differently affected learning, motivation, and math anxiety between students with high and low anxiety. The results of their study showed that the AR group performed better than the non-AR group, and high-anxiety learners in the AR group outperformed in algebra and geometry. The AR group had higher motivation based on Keller's ARCS model. The high-anxiety learners had higher confidence and satisfaction and lower anxiety when learning using mobile AR. The AR users were satisfied with ease of use, usefulness, playfulness, and benefit from exploration and hands-on experiences. Moreover, high-anxiety users in the AR group had higher perceptions of exploration, hands-on experiences, and playfulness. The results of their study portrayed that the way the students perceived the lesson depends on how they learn effectively.

Tsai (2020) has a similar study that aims to examine the differences in students' English vocabulary learning performance as well as the instructional materials motivation, comparing the traditional lecturing method and the Augmented Reality method. Their study adopted an unequal pre-test and post-test experimental design. The results showed that the instructional materials, motivation and performance of the students taught using AR were superior to those of students taught using the traditional lecturing method. Their study showed that traditional discussions of teachers motivates the students less compared to the usage of Augmented reality like SIMaTAR.

A review of augmented reality systems and their effects on mental workload and task performance was conducted by Jeffri & Rambli (2021). They had found a positive correlation between effects on mental workload and effects on task performance. They explained that if the effect on mental workload is positive, then the effects on task performance are more likely to be positive as well, and vice versa. According to them the effectiveness of AR systems was shown to be influenced by the type of AR display device used, relevance and timeliness of content, information presentation, user characteristics and task characteristics. Such finding is in unison with Pirker (2017) who found out that AR yields positive learning outcomes as it provides students with excellent interactive and practical experience. The same is true in the study of Craciun & Bunoiu (2017) which revealed how AR enhances students' practical and cognitive skills and how it offers a creative approach to education.

Augmented reality (AR) applications can be used in almost all education and training environments. A study administered by Kaya & Bicen (2019). reveals the relationship between perceived usefulness, utility and attitudes regarding the use of AR applications in educational environments as well as the relationship between attitude levels and academic achievements. It also reveals the effect of AR application use on academic achievement in education. The researchers found that the perceived benefit and ease of use of augmented reality (AR) applications in educational settings strongly influence attitude levels in a positive direction, that there is no meaningful relationship between attitude levels and academic achievement, and that the use of augmented reality (AR) applications in educational processes raises students' academic achievement.

The increase of the scores of the students from Pre-test to Post-test indicates the effectiveness of SIMaTAR augmented reality application in improving the students' performance. According to the students they would retain the knowledge they acquire using the SIMaTAR application because they had the power to manipulate the 3D images. Students claimed that the lessons can be understood and perceived easier using the SIMaTAR augmented reality application. Also, their interest was easily captured by using the SIMaTAR augmented reality application. They tend to listen attentively and become more curious to learn something new because he SIMaTAR augmented reality application is somewhat new to them.

Challenges and issues of using SIMATAR mobile augmented reality application of the students in science

Table 7 displays the results regarding the challenges and issues of using SIMATAR mobile augmented reality

application of the students in science. It revealed that the students agreed that they have difficulties related to their abilities because of being the pioneers in AR-enabled subjects (3.6), lack of appropriate instructional support in AR applications (3.7), and they agreed that real environments are different from virtual environments (3.7). The students found the SIMaTAR challenging because they are pioneers and they think that real environments are different from virtual environments.

The students moderately agreed that they lack equipment and need tools that are high cost (smartphones, tablets, etc) (3.15) because some of them don't have personal cell phones and they rely on piso nets in their neighbors. Also, they have a difficulty in focusing on learning because they get distracted if they use their gadgets while learning (2.8) and they don't have sufficient time to study at home (2.75) especially during modular learning because their parents make them do the house chores. However, the students disagreed on lacking cognitive load and learning motivations (2.3) and having no content for practice in the AR system (2.3). The students' difficulties in manipulating AR being pioneers in using this technology are also unveiled in the study of Alalwan *et al.* (2020) who delineated that teachers are primarily concerned about the computer literacy of students for using AR. Enhancing students' literacy skills in terms of manipulating new technologies such as computers and mobile gadgets is a requisite for effective application of AR in the classroom. The same authors also expressed that there is a lack of instructional design in the application of AR which may negatively affect students' willingness to use AR properly. According to Akçayır and Akçayır (2017) augmented reality offers unique advantages, such as its "combination of virtual and real objects in a real setting." But, as with all technologies, there are some challenges to be considered when using AR. According to them, The Internet

Table 6: Students' challenges and issues of using SIMATAR mobile augmented reality application of the students in science

Challenges by the Students using SIMATAR mobile application	Weighted Mean	Verbal Interpretation
Have difficulties related to their abilities because of being the pioneers in AR-enabled subjects.	3.6	Agree
Lacking cognitive load and learning motivations	2.3	Disagree
Lack of equipment and need tools that are high cost (smartphones, tablet, etc)	3.15	Moderately Agree
Lack of appropriate instructional supports in AR applications	3.7	Agree
Difficulties in understanding the content of the subject or cognitive overload	2.8	Moderately Agree
No content for practice in the AR system	2.3	Disagree
Have difficulty focusing on the learning objectives	2.55	Moderately Agree
Lack of sufficient time to study	2.75	Moderately Agree
Lack of gadget or internet connectivity for activities that require internet surfing	3	Moderately Agree
Real environments are different from virtual environments	3.7	Agree

and other ICTs as tools and catalysts for sustainable development: innovation for the 21st century. Same with the students, the teachers also have some challenges and issues upon using the SIMaTAR Application. A study conducted by Alalwan *et al.* (2020) determined the challenges and prospects of virtual reality and augmented reality utilization among primary school teachers. It was determined that lack of competency, limited instructional design, lack of focused attention, Time constraints and a lack of resources in the environment were frequent obstacles to the use of VR and AR. According to reports, teachers rated AR's usefulness higher than VR's. This perception may be related to the fact that AR typically offers features that are simple to use and take little time for users to understand. Additionally, compared to VR, which often calls for more specialized hardware and software setup, handheld AR was thought to offer an accessible way for primary school pupils to understand science. Teachers' main worries about internet speed and availability were addressed through AR, which would allow students to access course materials even when they are not connected to the internet (Carrera & Asensio, 2017).

A review conducted by Hwang (2016) that focused on the challenges analysis for using augmented reality in education'. They conclude from their literature review that AR strongly supports the educational process. However, after they compared the research studies, they noted that the effect of AR in education is not different from that of traditional methods. Based on their review some studies suggest that AR causes a higher cognitive load and suggests that AR reduces cognitive load. The researchers acknowledge that selecting the right AR applications for each purpose and usage strategy is the biggest problem. Lack of knowledge, technological issues, the user interface of the application, teachers' failure-related fear, and time

constraints (lecture time is limited or insufficient). The researchers believed that if these difficulties are overcome, augmented reality programs like SIMaTAR will be a very useful tool in education. Other costs (such as the cost of smartphones and tablets), the Internet, and technical issues are additional factors in challenges in using the SIMaTAR application. Challenges and issues in educating the students is inevitable. Learners and teachers may face different challenges along the way but one thing is important is the knowledge that the students can acquire in the usage of any kind of technological innovations.

CONCLUSION

It can be concluded that integration of SIMaTAR in teaching Science increases the engagement and interest of the students in learning the subject. Moreover, using AR technology helps the students in understanding the lesson better for they are able to manipulate and view 3D images. Results showed that all indicators on the teachers and students' assessment on SIMaTAR mobile augmented reality application were rated as strongly agree with an overall mean of 4.9 and 4.40, respectively. All indicators of students' attitude towards science showed improvement after implementing the AR application in science teaching. Indeed, AR does not only improve motivation but also it also facilitates more student-students and teacher-student interaction. Moreover, the scores of the student participants in their Pre-Test and Post-Test presented that all of the student participants remarkably had an increase of their scores after using the application, from a computed mean of 9.9 in the pre-test it increased to 15.35 during the post test. The increase of the scores of the students in their Post-Test indicates that they have improved after learning the lessons using the SIMaTAR application. As for the challenges, results revealed that students do not have the gadgets to use and they lack the knowledge on how to manipulate the augmented reality application.

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