

SCI-AR: ENHANCE SCIENCE LEARNING
THROUGH AUGMENTED REALITY



AN UNDERGRADUATE THESIS

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BACHELOR OF SCIENCE IN INFORMATION TECHNOLOGY

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ABSTRACT

Science education can be challenging for students with specific learning difficulties, as it involves abstract concepts and requires a high level of cognitive performance. This can make it difficult for all students, regardless of whether they have specific learning difficulties or not. This study aims to help students to be more engaging on science learning and help them to easily understand science concepts using Mobile Augmented Reality Application for learning science. Moreover, using TAM theory, the study intends to assess the system's adoption and efficacy. The researchers employ a questionnaire with a 5-point Likert scale. Responses are gathered from a total of 41 respondent of Grade 5 students at Tubod Elementary School. The participants were tasked with interacting with the Mobile Augmented Reality App. Consequently, most of them agreed to use the Sci-AR following its assessment. Furthermore, the evaluation outcomes indicate that the students have a favorable attitude and positive perception towards the Sci-AR Application.

Keywords: augmented reality, science augmented reality, mobile augmented reality, science mobile augmented reality, acceptance level

DEDICATION

This study is dedicated to God, to my family, and to my real friends, who supported me along the way throughout my struggles and silent battles who never left me. To all my cats who also cheer me up whenever I feel down, Thank You. They are my inspiration to keep moving forward despite the heavy blow of life. Their prayers and support will be strength until the day thy end.

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CHAPTER 1

INTRODUCTION

This chapter will introduce the issue addressed by the study, as well as its proposed solution. It will also describe the functions of the system, identify its limitations, and discuss the significance of the research.

Background of the Study

Students with specific learning difficulties often struggle with learning science, as it encompasses abstract concepts and demands a high level of cognitive performance, making it challenging for all students, regardless of whether they have specific learning difficulties or not. Similarly, primary school students struggle with fully grasping complex and abstract ideas, such as basic concepts in astronomy. The abstract nature of these concepts hinders their comprehension, leading to a negative impact on their overall attitude towards the subject (Sahin and Yilmaz, 2020); (Turan and Atila, 2021).

Additionally, Sahin and Yilmaz (2020) noted that to address these challenges, it is crucial to enhance the understanding of abstract scientific concepts by incorporating visual aids in the teaching process. Moreover, one of the emerging technologies that is still new to education but shows great potential is Augmented Reality (AR). Augmented Reality (AR) is an emerging technology that finds applications in diverse educational contexts (Jessup et al., 2019). Liono et al., (2020) also noted that using visualization is considered one of the most effective learning methods as it makes the subject more engaging and helps students comprehend the concepts better.

The mobile application will run on Android Operating System and will only support later version of Android as long as it also supports Augmented Reality. The researcher uses Unity3D and ARFoundation/ARCore in the development of the mobile application. Unity3D is a cross-platform game engine used to develop video games for computers, consoles, mobile devices, and websites. It provides tools for creating and manipulating 3D graphics, physics simulations, animations, and user interfaces. ARFoundation/ARCore is a platform developed by Google for building

Augmented Reality (AR) experiences on mobile devices. It uses a combination of sensors and the SLAM (Simultaneous Localization and Mapping) algorithm to enable devices to understand and interpret the environment around them, and then overlay virtual objects on top of the real world.

The Technology Acceptance Model will be the theory to create the system. The approach consists of four main factors: perceived ease of use (PEU), perceived usefulness (PU), attitudes toward technology use (ATU), and behavioral intention (BI). Together, these four main factors help to predict a user's intention to use a technology.

Lastly, this research paper presents a distinctive method to help students' increase motivation and gaining their confidence in learning science, without eliminating the traditional teaching approach.

Research Objectives

In this section, the researcher identifies both broad and particular aims.

General Objectives

The primary goal of the study is to develop a Mobile Augmented Reality Application for Grade 5 Students of Tubod Elementary School in Iligan City. This study used the Technology Acceptance Model to evaluate the Mobile Augmented Reality Application and Specifically, this study aims to:

Specific Objectives

The primary objective of the study is to:

1. Develop a Mobile Augmented Reality for Science Learning, which includes the following functionalities:

- 1.1 Animated 3D models
- 1.2 Informative 3D models
- 1.3 Note keeper

2. Assess the effectiveness and acceptance of the Mobile Augmented Reality Application by students through the utilization of the Technology Acceptance Model.

Scope and Limitation of the Study

The main emphasis of the research is to develop a Mobile Augmented Reality Application for learning science that will help students to be more engaging on science learning and help them to easily understand science concepts, which will be conducted within Tubod Elementary School, Tubod, Iligan City, specifically for Grade 5 Students.

The researcher's focus is solely on creating a Mobile Augmented Reality Application, which may include the functionalities mentioned in the previous section of the study. Additionally, the researcher utilized ARFoundation/ARCore to implement Augmented Reality and enable the superimposition of 3D objects or models onto the augmented world.

The algorithm, SLAM, which is already included inside ARCore SDK and Unity3D a game engine, will be the in charge to overlay the 3D models and determines the device position and orientation.

Moreover, in evaluating the application's usability and potential for adoption, the study will utilize the Technology Acceptance Model (TAM). The TAM variables to be assessed include:

Perceived Usefulness (PU): Perceived Usefulness is a measure of the user's perception of how beneficial the Mobile Augmented Reality Application will be in enhancing their science learning experience. It gauges the extent to which students believe that using the application will improve their understanding of science concepts and engagement with the subject matter (Davis, 1989).

Perceived Ease of Use (PEOU): Perceived Ease of Use refers to the user's perception of how easy it is to use the Mobile Augmented Reality Application. It evaluates the simplicity and user-friendliness of the application and how intuitively students can navigate and interact with the augmented content (Davis, 1989).

Attitude towards Using (ATU): Attitude towards Using measures the student's overall positive or negative feelings and evaluations regarding the

utilization of the Mobile Augmented Reality Application. It is influenced by the perceived usefulness and perceived ease of use and significantly impacts the intention to use the application (Davis, 1989).

These variables will be assessed within the context of the Grade 5 students at Tubod Elementary School, Iligan City, to determine the potential impact and acceptance of the Mobile Augmented Reality Application for science learning. The assessment will consider how these variables influence the students' acceptance and intention to use the application, which, in turn, affects their engagement and understanding of science concepts.

Other platforms, devices and documentation tools are not included in the study. Moreover, the application lacks three key functionalities. First, it does not offer the capability to create lessons. Second, it does not provide the option to generate quizzes within the application. Third, the app operates without requiring users to create accounts, thus eliminating the need for an account creation feature.

Significance of the Study

This research will be valuable for individuals who intend to utilize the system in the future, including students.

- Students will benefit from this application by using it for learning and understanding science easily.
- Future researchers can benefit from the system developed in this study as it provides not only assistance to students but also serves as a valuable source of ideas and inspiration for those interested in pursuing similar research.

Analytical Framework

This section aims to provide users with a quick comprehension of how the system functions, aiding them in understanding the system better.

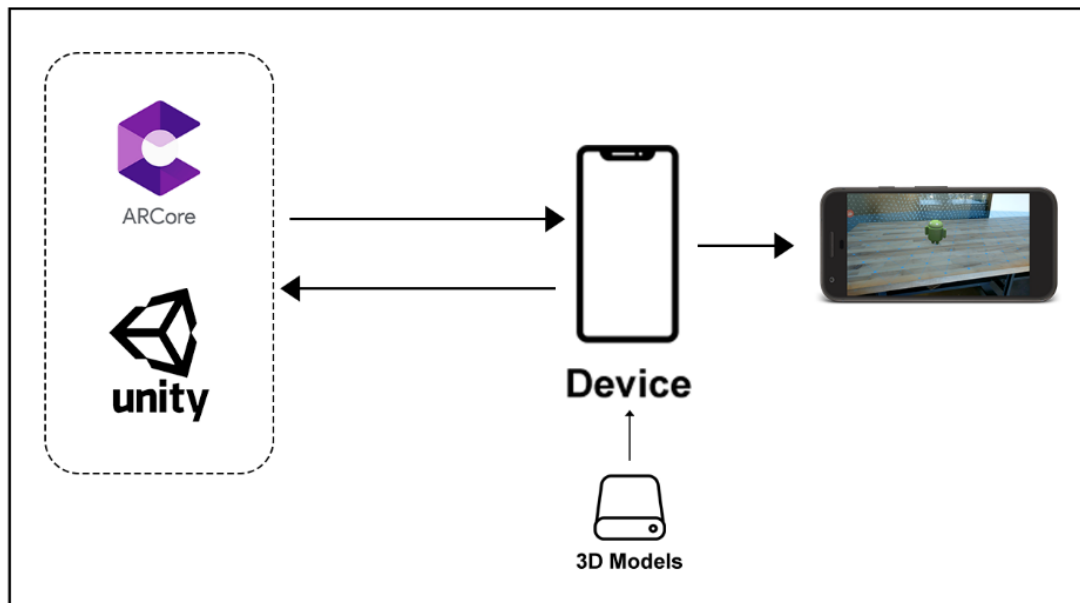


Figure 1. Augmented Reality Workflow Diagram

The figure above shows the basic workflow/process of the AR App. The process of projecting a 3D model into the augmented world through Augmented Reality involves the device communicating with both the Unity3D Engine and ARCore SDK. To achieve this, ARCore utilizes the SLAM algorithm to determine the device's current position, location, and orientation in the real world. Initially, the 3D model is stored within the application itself, and then it proceeds to the Unity3D engine, where the texture and shape of the model are applied. ARFoundation/ARCore then gathers the device's position and orientation information to determine the 3D model's position in the real world. Finally, ARFoundation/ARCore places the 3D model in the augmented world while continuously collecting device position and orientation data.

The Conceptual framework shows the connection between the system and users, where users can interact with the system by accessing it and using the AR feature by pointing the camera to an image. Additionally, users can create notes

within the app, which can be overlaid on the AR. These notes will then be stored in the app's database.

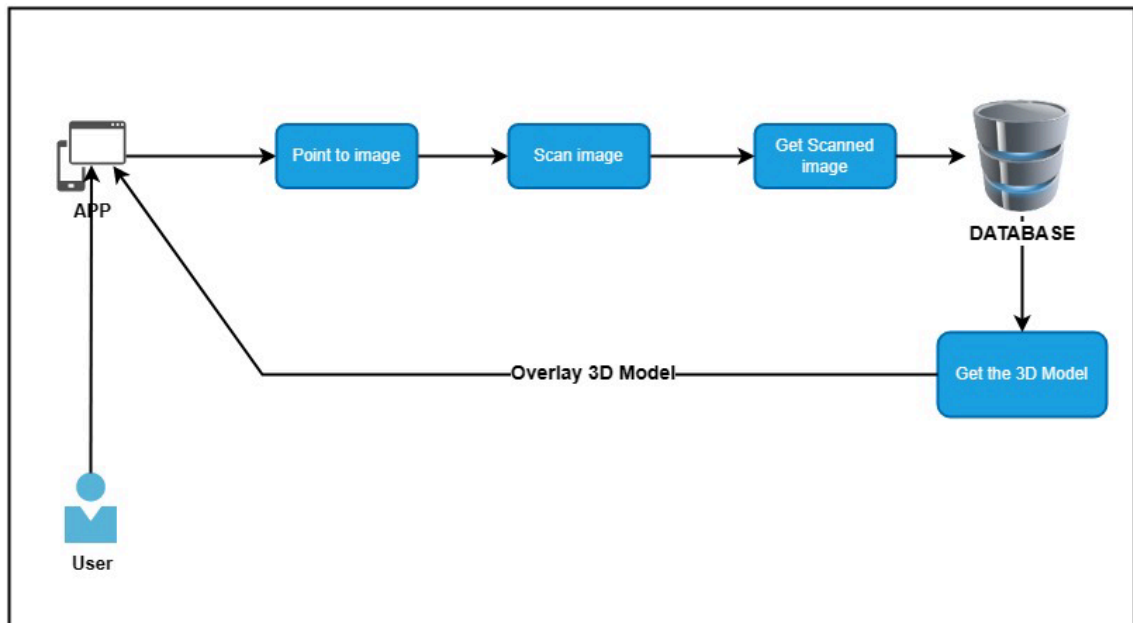


Figure 2. Sci-AR – Getting 3D Model from database

In Figure 2. The diagram shows how the system works every time the user tries to scan an image to display a 3D model. First, the user points the phone's camera into an image and then the system will try to identify the image as it scans and check if the image does exist in its database. After the system identifies the image, the system will retrieve the specific 3D model that is bound for that image and display it the 3D space of Augmented Reality.

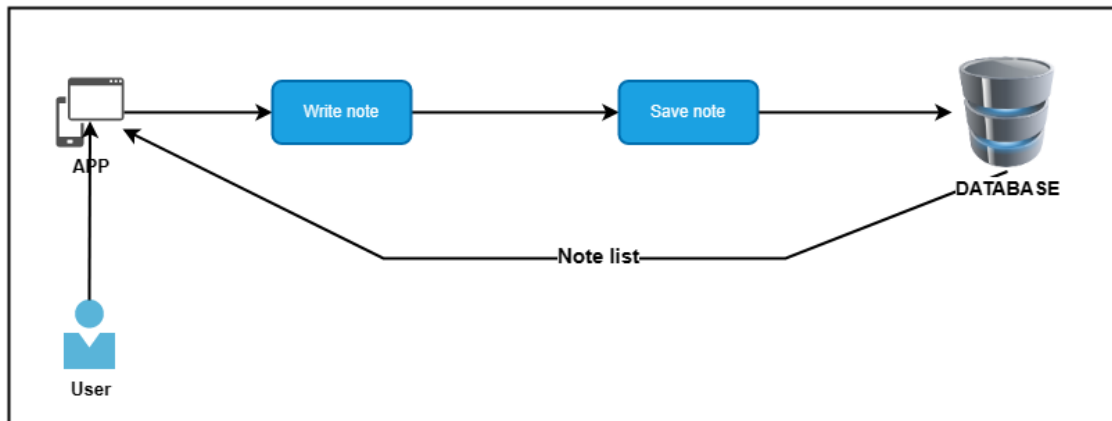


Figure 3. Sci-AR – Creating/Writing

Figure 3. shows the workflow diagram of note system where whenever the user creates a note and then saving the note. The created note will be saved in a database and then later will be retrieve to be displayed the list in note menu.

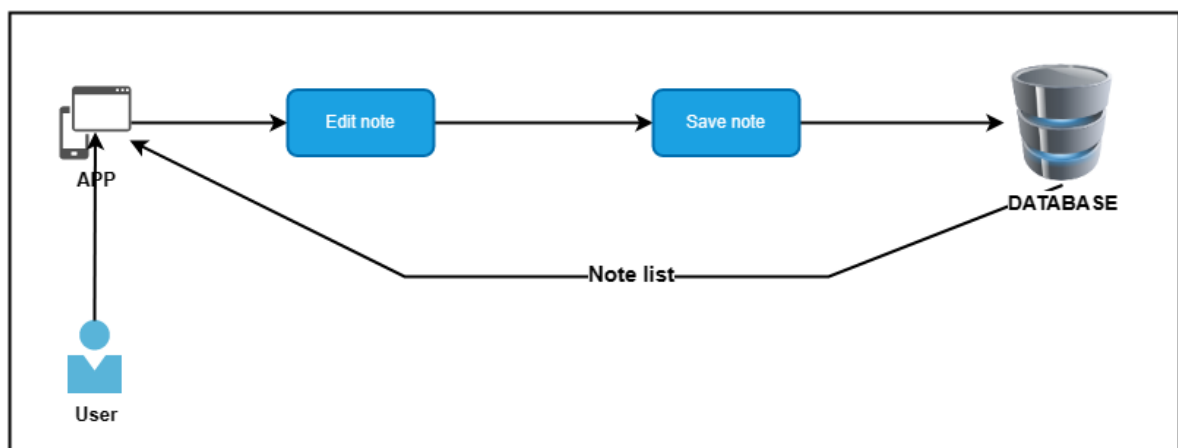


Figure 4. Sci-AR – Editing existing notes

In the Figure 4., the diagram shows the system flow when the user edits a note. The user will pick an existing note from the note list and then the picked note will be retrieved from the database. After the finished editing, the note that was saved on the database will be updated.

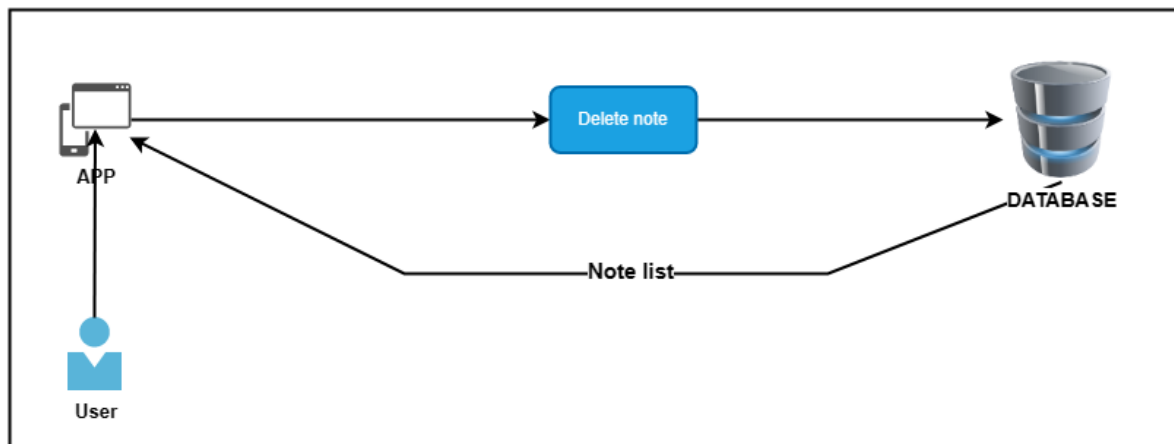


Figure 5. Sci-AR – Deleting existing notes

In this Figure 5., it shows whenever the user deletes a note. The user picked a note from the note list and the system will delete the picked note from the database

These are the actions that a user can perform:

- a.) Use Augmented Reality – the ability of using augmented reality
- b.) Create Notes – the ability to create notes
- c.) Edit Notes – the ability to edit existing saved notes
- d.) Delete Notes – the ability to delete existing saved notes

The Theory Used in the Study

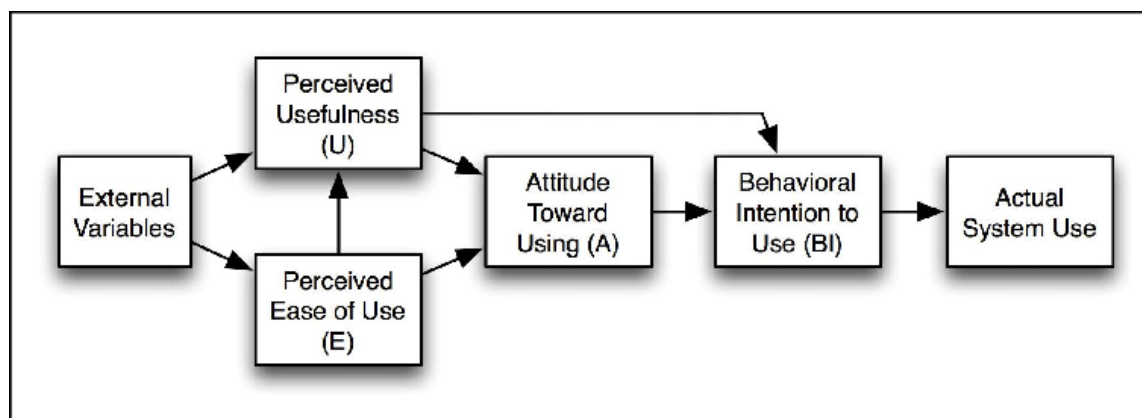


Figure 6. Technology Acceptance Model

The Technology Acceptance Model (TAM), which was first presented by Fred Davis in 1986, was described by López et al. (2019). The model indicates that

the acceptance of technology for the learning process is influenced by the beliefs and behaviors of its users, as well as the perceived value and ease of usage. Furthermore, TAM is the most widely adopted model and has been used to explain technology acceptance in numerous studies. Additionally, TAM has gained widespread acclaim for its ability to predict students' acceptance of technology and explain their perceptions of embracing technology.

Moreover, by using TAM, the researcher can explore the factors that influence students' attitudes and intentions towards using the Augmented Reality application, such as perceived usefulness, ease of use, and social influence. Additionally, the Technology Acceptance Model (TAM) offers a theoretical framework to identify the factors that impact the adoption of technology, such as Augmented Reality (AR), and how it can affect the learning outcomes of children (Purwaamijaya, 2019).

This will help to ensure that the application meets the needs of the users and is effective in enhancing science learning among Grade 5 students at Tubod Elementary School in Iligan City.

The TAM theory consists of four main factors: perceived ease of use (PEU), perceived usefulness (PU), attitudes toward technology use (ATU), and behavioral intention (BI). In addition, the variability of these four main components can be influenced by factors such as gender, age, experience, and voluntariness of the study participants. Furthermore, the model postulates that the acceptance of a new technology or system is predicated on the levels of Perceived Ease of Use (PEU) and Perceived Usefulness (PU), which in turn influence Behavioral Intention (BI) after being mediated by Attitude Toward Usage (ATU) (Davis, 1989).

Perceived Usefulness (PU): refers to an individual's perception or belief about how using a specific technology can enhance their performance (Davis, 1989).

Perceived Ease of Use (PEU): refers to the extent to which an individual believes that utilizing a specific technology will be effortless (Davis, 1989).

Behavioral Intention (BI): BI is a measure that reflects the level of willingness of an individual to exert the necessary effort to perform a desired behavior, such as using computers.

Operational Definition of Variables and Terms

The operational definitions of the following terms were provided to facilitate better comprehension of the study:

Augmented world refers to a virtual environment created through augmented reality (AR) technology.

AR (Augmented Reality) is a technology that overlays digital information onto the augmented world.

3D models are digital representations of three-dimensional objects or environments that can be used in various applications such as games, simulations, and visualizations.

ARFoundation is a cross-platform development framework created by Unity Technologies for augmented reality applications. It enables developers to incorporate AR features such as image tracking and plane detection into their projects while supporting various platforms like iOS, Android, and Windows.

ARCore is a software development kit (SDK) developed by Google that enables the creation of augmented reality (AR) applications for mobile devices.

Android is a mobile operating system developed by Google.

Devices refer to electronic tools or machines designed to perform specific tasks or functions. Android Device will be used for AR.

Device position and orientation: refers to the spatial location and orientation of a device. It will be used for AR to project the model.

Game engines are software platforms designed to help developers create video games.

SLAM (Simultaneous Localization and Mapping) is a technology used in robotics and computer vision for mapping and navigating an environment.

SDK stands for software development kit and is a collection of software development tools that allow developers to create applications for specific platforms.

SQLite is a relational database management system that is designed to be embedded into software applications.

Students, as the system users.

TAM (Technology Acceptance Model) - model for understanding how users

perceive and adopt new technology.

Unity3D is a game engine used for developing 2D and 3D video games.

CHAPTER 2

REVIEW OF RELATED LITERATURE

This chapter presents an in-depth analysis of the problem addressed in this study, along with its proposed solution.

Augmented Reality

Over the past few decades, the integration of technology in education has brought about a significant change in the way knowledge is imparted to students. With the use of technology combined with effective teaching methodologies, there has been a surge in the development of innovative techniques that aim to enhance the quality of the teaching and learning experience and one such example of technology is Augmented Reality (AR).

Augmented Reality (AR) is a technology that overlays digital content onto the physical world, creating an immersive and interactive user experience. Furthermore, the word "augmented" in "augmented reality" means to enhance or improve something by adding elements to it. In the context of technology, it refers to the enhancement of the physical world through digital elements, such as graphics, sounds, and other sensory inputs, which are overlaid onto real-world objects or environments in real time. This creates an immersive experience that blends the digital and physical worlds together. Moreover, Augmented reality employs two distinct tracking methods: marker-based tracking and markerless tracking. Marker-based tracking utilizes markers with a black and white pattern, featuring a bold black border on a white background. In contrast, markerless tracking can work with markers of any shape. Marker-based tracking is particularly well-suited for paper-based media, as it allows for the display of interactive 3D objects directly above the marker's position on the paper. Users can interact with the augmented content by moving or sliding the paper with the marker (Andrea et al., 2019).

Furthermore, according to Cabero-Almenara and Gimeno. (2019), Augmented Reality (AR) is a developing technology that is becoming more prominent in the field of education. When combined with mobile technology, AR is

considered to be one of the most effective tools for facilitating meaningful and widespread learning. Additionally, Augmented Reality (AR) has the potential to revolutionize the way educational materials are presented across all levels of learning, from public outreach events to advanced teaching at the undergraduate and postgraduate levels. The appeal of AR as a teaching aid lies in its capacity to provide a blended learning experience that combines the virtual and real-world environments or materials in the classroom (Barrow et al., 2019) and has the potential to enhance student learning motivation and lead to improved academic achievement (Khan et al., 2019). Besides, it offers a superior user experience as a result of its ability to showcase 3D virtual information and facilitate interaction (Majeed and Ali, 2020).

Similarly, Sahin and Yilmaz (2020) also noted that Augmented Reality (AR) is significant in presenting abstract ideas in a tangible form that matches students' comprehension level, and it allows for the observation of events and objects that would be impossible to experience in real life.

Technology Acceptance Model (TAM) Theory

The Technology Acceptance Model (TAM), a theory of information systems, simulates how consumers adopt and use technology. The point at which humans employ technology is during real system use. People utilize technology for a variety of reasons, one of which is behavioral purpose. TAM and its expansions have found usage in a variety of applications across many fields, settings, and places, providing a crucial theoretical tool for forecasting user behavior.

With perceived ease of use and perceived utility as the two main criteria affecting a person's desire to utilize new technology, TAM has been one of the most prominent models of technology acceptance. It has been used in many different sectors, including business, healthcare, and education.

The Technology adoption methodology (TAM) assessment methodology, which was first presented by Fred Davis in 1986, is described by López et al. (2019) and shows that adoption of a technology for the learning process is impacted by beliefs. The behaviors of its users, as well as the perceived value and simplicity of usage.

According to Jang et al. (2021), Several models have been proposed to explain technology acceptance, including the Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM), and Unified Theory of Acceptance and Use of Technology (UTAUT). Among these models, TAM is the most widely adopted and has been used to explain technology acceptance in numerous studies. The TAM has gained widespread acclaim for its ability to anticipate teachers' adoption of technology and to explain their perceptions of teachers' embrace of technology.

Simultaneous Localization and Mapping (SLAM) Algorithm

SLAM, or simultaneous localization and mapping, is a method used in computer vision and robotics to create or update a map of an uncharted area while simultaneously keeping track of an agent's location inside it. We may employ SLAM techniques in the augmented reality experience to add virtual objects based on the user's observation point (location) and environment structure. Similarly, Singandhupe and La (2020) explained that Simultaneous Localization and Mapping (SLAM) is an algorithm that enables a robot or sensor system to perceive its environment using sensors and estimate its own position in the environment at the same time.

As an example, Liu et al. (2019) cited that for registering both actual and virtual environments in AR, tracking registration technology is essential. The tracking registration method must be able to reliably and swiftly follow a moving subject robustly and in real time, which is more difficult given the irregular camera motions in mobile AR. Additionally, Tang and Cao (2020) also noted that AR technology requires attention to three primary aspects: three-dimensional registration, authenticity in virtual-reality fusion, and effective human-computer interaction. Of these aspects, three-dimensional registration is particularly crucial as it plays a central role in achieving convincing virtual fusion effects. Therefore, one of the primary techniques for 3D registration is Simultaneous Localization and Mapping (SLAM), which is capable of determining the device's position in real-time even in unfamiliar environments (Li et al., 2019).

In addition, ARCore, an augmented reality (AR) platform developed by Google that enables developers to create AR experiences for Android devices. It uses the device's camera, sensors, and motion processors to understand the

environment and place virtual objects on top of the real world. Overall, ARCore's use of SLAM technology allows it to create accurate and stable AR experience.

To sum up, Augmented Reality (AR) has emerged as an innovative technology that provides students and teachers with a unique learning experience in science education. The benefits of AR for education are numerous, including enhanced engagement, improved comprehension, and increased motivation.

CHAPTER 3

METHODOLOGY

The methods and procedures employed by the researcher were utilized to facilitate the development and construction of the suggested system.

Research Design

The researcher utilized the Agile Methodology Model for the development of the system. The Agile methodology is a framework for software development that emphasizes collaboration, an iterative approach, and adaptability throughout the software development process (Rachmawati et al., 2021).

Moreover, according to Kaliparambil (2022), the mobile app development process using Agile methodology is highly adaptable, enabling the researcher to customize the timeline based on specific requirements and preferences. This approach prioritizes incremental improvements and offers flexibility in organizing software and mobile app development efforts.



Figure 7. Agile Methodology

The aim of this study is to utilize the Agile methodology to create a Mobile Augmented Reality for Science Learning, which will serve as a learning and assessment tool for Tubod Elementary School Grade 5 Students and the general public. This will be achieved through the implementation of the six phases of the Agile methodology.

- a) **Requirements Phase** - In this phase, the scope of the project determines, prioritize important tasks, and establish key requirements with the client. The requirements will be kept minimal and can be added to later on.
- b) **Design Phase** - In this phase, an analysis will be performed to determine the appropriate business logic, database models, and technical requirements (languages, data layers, services, etc.) needed to meet the requirements from the previous phase.
- c) **Development and Coding Phase** - With the planning and analysis out of the way, the actual implementation and coding process can begin. All planning, specification, and design docs up to this point will be coded and implemented into this initial iteration of the project.
- d) **Integration and Testing Phase** - Once the current build iteration has been coded and implemented, the next step is to go through a series of testing procedures to identify and locate any potential bugs or issues that have cropped up.

These were the procedures observed:

1. Testing the proposed Mobile Augmented Reality Application against the major system.

The previous section mentioned certain functionalities or processes, namely:

System Testing - This test encompasses all the processing scenarios that were evaluated by the system against the expected performance of different users.

Unit Testing - The researcher conducted unit testing to identify and eliminate errors that could cause the program to terminate unexpectedly

- e) **Implementation and Deployment Phase** - After successful testing, the system is ready to be implemented and deployed.
- f) **Review Phase** - Once the system is deployed, it will undergo review to determine any improvements or adjustments that need to be made for the next iteration.

Physical Environment and Resources

In addressing the physical environment and resource requirements, it's crucial to highlight the hardware prerequisites necessary to design and execute the suggested system effectively.

Hardware

The following computer hardware requirements are necessary to design and execute the suggested system.

Mobile Device:

- Android 8.1 Oreo is the most palatable mainstream Android version yet. It is visually consistent, simplified, feature-rich and polished.
- Qualcomm Snapdragon 636 refers to an Octa-Core Processor that comprises eight Kryo 260 cores, which can operate at a maximum clock frequency of 1.8 GHz. The Kryo 260 Cores outperform the ARM Cortex-A53 Cores of SD 630 by 40% in terms of performance. Moreover, MediaTek Helio G35 is a chip that employs an octa-core processor built on 12nm architecture. However, it does not feature the faster A55 or A7x cores, but only Cortex-A53 cores. The processor runs at a speed of 2.3GHz and can support up to 6GB of RAM, which is of the LPDDR4x type with a frequency of 1,600MHz. The chip can also accommodate cheaper LPDDR3 memory with a maximum capacity of 4GB.
- A minimum of 4GB RAM is required for web browsing, social media, video streaming, and some popular mobile games, although the amount of RAM required varies depending on the apps you use (Phillips, 2022). Furthermore, gigabyte (GB) is a measure of digital information equivalent to one billion bytes. It refers to the size of a computer file or software that contains a billion bytes.
- With 64GB, you'll have enough if you use your phone for WhatsApp and calls. In addition, you have space for some social media apps and light games.

- The graphics card should be Adreno 509 for Snapdragon Chipsets and GE8320 for MediaTek Chipset or later that can support Augmented Reality (AR). A chipset refers to a collection of integrated circuits or motherboard chips that are interdependent and responsible for regulating the movement of data and instructions between the CPU or microprocessor and external devices. A graphics card, also known as a display adapter or video card, is a component found in most computing devices that is responsible for rendering graphical data with high clarity, definition, color, and overall visual quality.
- The Camera must at least clear and not blurry in order for ARCore to work correctly.

Provided that the mobile device satisfies the following requirements - Android 8.1 or a later version, sufficient storage space, a high-resolution camera, and support for Augmented Reality, the application can display Augmentation and projections of models without any issues. However, the performance of the system or application depends on how well it is developed.

Software

In terms of software, these are the things that are recommended according to online searches gathered by the researcher.

- C# (pronounced "See Sharp") is a modern, object-oriented, and type-safe programming language created by Microsoft. C# enables developers to build many types of applications such as Windows client applications, Web services, database applications, and more.
- Unity3D is a cross-platform game engine used for developing 2D and 3D games, simulations, and interactive experiences. It will be used to develop the mobile augmented reality application.
- ARCore is a software development kit (SDK) developed by Google that enables the creation of augmented reality (AR) experiences on Android devices. It will be used to project 3D Objects on real world. ARCore uses

Simultaneous Localization and Mapping (SLAM) Algorithm to map the environment and place digital objects in the real world.

- SQLite is a software library that provides a relational database management system. It is designed to be a self-contained, serverless, transactional SQL database engine. SQLite is one of the most widely deployed databases in the world, as it is integrated into many operating systems, browsers, mobile devices, and other software products.

Tools and Techniques to be Used in the study

The methods and instruments employed to complete the study consist of utilizing Use Case to demonstrate the capabilities available to the user, and utilizing Activity Diagram to illustrate the interaction between the user and the system.

Use Case Diagram

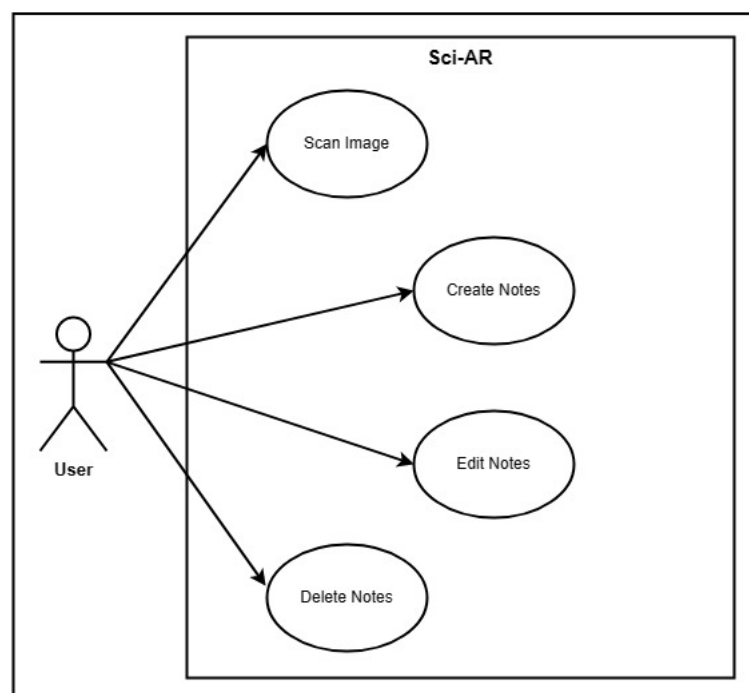


Figure 8. Use Case Diagram

A use case diagram is a form of visual modeling that depicts the main components and how they interact in a system. They can be used to identify the

major parts of a system and how they interact, which is helpful in ensuring that all necessary steps are taken in order to complete a task. They are also helpful for discovering potential areas for improvement (Mahr, 2023).

Use Case Diagram Description Table

Use Case	Description
Scan Image	When user scan an image
Create notes	User create notes
Edit notes	User edit existing notes
Delete notes	User delete existing notes

Table 1. Use Case Diagram Description Table

As shown in the Figure 8, a use case outlines the manner in which an individual utilizing the process or system will achieve an objective.

The user can use the augmented reality with the adherent science book. Additionally, the user can also take a note to save some information and can also later be edit or deleted.

Sequence Diagram

Sequence diagram is used to depict the interactions between objects in a system in a sequential order. They are primarily used by developers and business analysts to comprehend project requirements. These diagrams demonstrate the interactions between various parts of the system and the order in which they occur. They display the elements as they interact over time, where the objects are placed on the horizontal axis and time on the vertical axis. The horizontal axis represents the objects interacting with each other, while the vertical axis represents the progress of time (Ijaz, n.d).

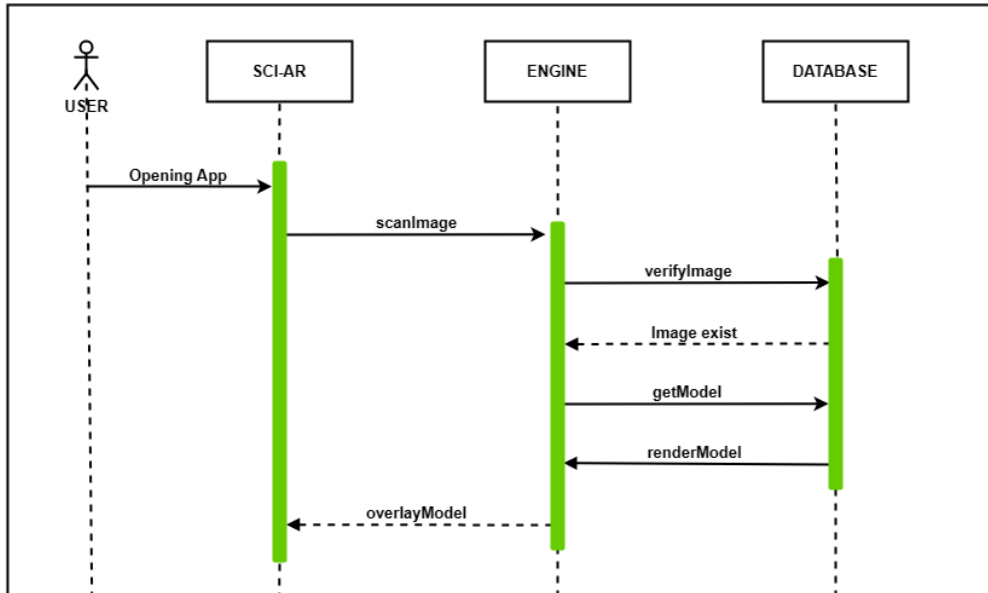


Figure 9. Sequence Diagram

Figure 9. illustrates the application's sequence diagram. The user will open the app and instantly be brought to a camera-like UI. Afterwards, the user can use the app to point at the images in the book, and the app will scan the image with the scanImage function and check its existence in the database using the verifyImage function. After verifying its existence, the app will retrieve the corresponding 3D model using getModel function and overlay it into the real world.

Activity Diagram

Activity diagram is a modeling tool that is utilized to represent the sequential workflow of a significant activity. It concentrates on the sequences of actions and their corresponding conditions for initiation. The state of an activity is linked to the execution of each step of the workflow.

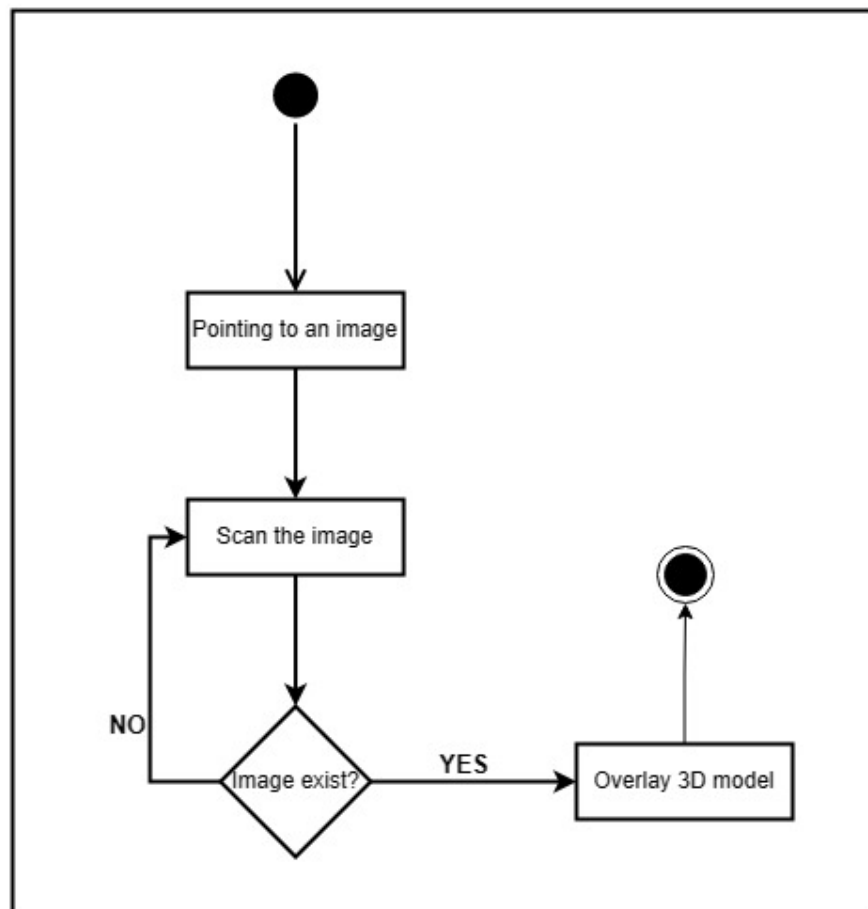


Figure 10. Activity Diagram

Figure 10. illustrates a simplified diagram of how the system functions. Initially, the user will be directed to a camera-like UI, which they can utilize to point to an image in the book. The application will then automatically scan the image and check it against the saved images for AR in the database, which also has a corresponding 3D model. Once the model is confirmed, the app will retrieve the corresponding 3D model and overlay it onto the real world.

Field Name	Data Type	Data Format	Field Size	Description
note_id	INTEGER		255	Created note ID
Title	VARCHAR		255	Note title
date_created	VARCHAR	MM/DD/YY	255	Date note created
last_modified	VARCHAR	MM/DD/YY	255	Date note last modified
note_content	VARCHAR		255	Note content

Table 2. Sci-AR Entity Relationship Diagram

Research Site

The study will take place at Tubod Elementary School in Iligan City, serving as the primary research site for collecting and analyzing study data.

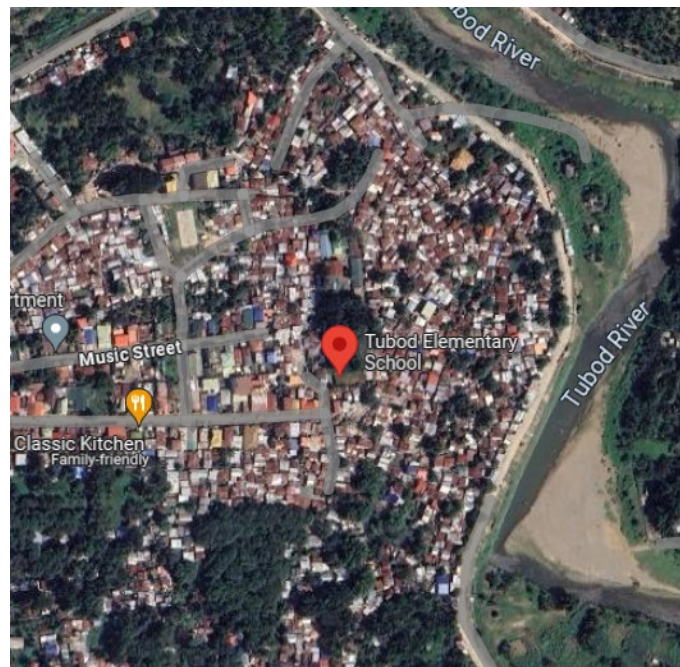


Figure 11. Tubod Elementary School (Source: Google Map)

Respondents/Informants/Sample and Sampling Method

The data for the research was gathered from students in the fifth grade, who served as the main data source since they possessed the necessary information for our study. The main source of data for the research will be fifth-grade students at Tubod Elementary School in Iligan City. The primary goal is to gather information from at least 50 participants, as mandated by the study's parameters.

Data Gathering Method: Instruments and Process

The survey utilizes questionnaires to present the survey questions. The researchers aim to collect 40 responses from fifth-grade students at Tubod Elementary School in Iligan City, focusing on the use of Augmented Reality in science learning.

The survey questions were strategically designed to gather information about the challenges and performance of Grade 5 students at Tubod Elementary School regarding their science knowledge and learning difficulties. The questionnaire is divided into three segments, aligning with the TAM theory, each carefully crafted to delve into specific aspects relevant to this research.

Additionally, in this section, the researcher provides a description of the table presented below, illustrating the scoring system and corresponding descriptions for each score.

Scale	Interval	Degree of Responses	Quality Description
5	4.20-5.00	Strongly Agree (SA)	Transformative Impact
4	3.40-4.19	Agree (A)	Significant Impact
3	2.60 - 3.39	Neutral (N)	Moderate Impact
2	1.80-2.59	Disagree (D)	Limited Impact
1	1.00-1.79	Strongly Disagree (SD)	Minimal Impact

Table 3. Likert Scale Used in the Questionnaire

Data Analysis Method

In this study, the researcher employed descriptive analysis to examine the data in the research project titled "Sci-AR: Enhance Science Learning Through Augmented Reality." By utilizing descriptive statistics, we gained insights into the types of science content that should be included in our Augmented Reality application.

To summarize the distribution of the variables, the researcher calculated various measures of central tendency and variability, such as the mean, median, mode, and standard deviation. These calculations allowed us to better understand the characteristics of our sample of respondents and identify any potential anomalies in the data.

In conclusion, descriptive statistics played a crucial role as the primary method of statistical analysis, enabling us to gain a deeper understanding of the characteristics of our respondents. Through this technique, we identified trends and presented the data in a meaningful way, providing valuable guidance for decision-making regarding our Augmented Reality application.

Research Ethics

The researcher prioritized ethical considerations throughout the data collection process in conducting this study. The following measures were implemented to uphold research ethics:

Informed Consent: Prior to conducting the interviews, the researcher obtained consent from the BED principal. The approval was sought through a formal letter signed by the dean and our advisor, clearly outlining the purpose, nature, and intended use of the provided information.

Respect for Participants: The survey was conducted in a respectful and professional manner, adhering to moral principles. The researcher ensured that survey participants felt valued and respected throughout the process.

Confidentiality: Any personally identifiable or sensitive data shared during the survey was treated with the utmost care to protect the privacy and confidentiality of the respondents. Only the research team had access to securely stored survey questionnaires.

Voluntary Participation: Respondents willingly participated in the survey, with the understanding that they could withdraw their consent at any time without facing any consequences.

Data Accuracy and Validity: The researcher provided survey participants with a questionnaire and offered clear instructions to minimize missing data and ensure data accuracy.

Institutional Approval: To further uphold ethical standards, the study project obtained necessary permissions from relevant institutional entities, including the dean's office and our advisor.

Use of Information: The information gathered from the survey was solely used for the specific research project on Sci-AR: Enhance Science Learning Through Augmented Reality. All provided information was treated with integrity and solely utilized for research purposes related to the project.

By adhering to these ethical guidelines, we safeguarded the safety and well-being of the participants, as well as the validity and integrity of the study process.

CHAPTER 4

RESULTS AND DISCUSSIONS

This portion presents the outcomes of the evaluation and analysis of the system. It encompasses the visual representation, examination, and elucidation of data obtained through the distribution of questionnaires to the participants. Additionally, it encompasses the tabular display of data accompanied by their corresponding explanations.

Objective 1: Develop A Learning App for Learning Science which include the following functionalities.

- I. **Note taking feature**
 - a. *Creating notes*

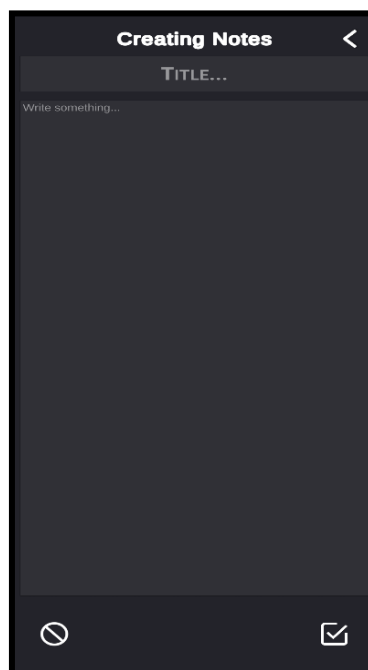


Figure 12. Note creation

Figure 12 shows the panel for creating notes where inside the panel there is two inputs which the top is for title of the note and the bottom is for the content of the note.

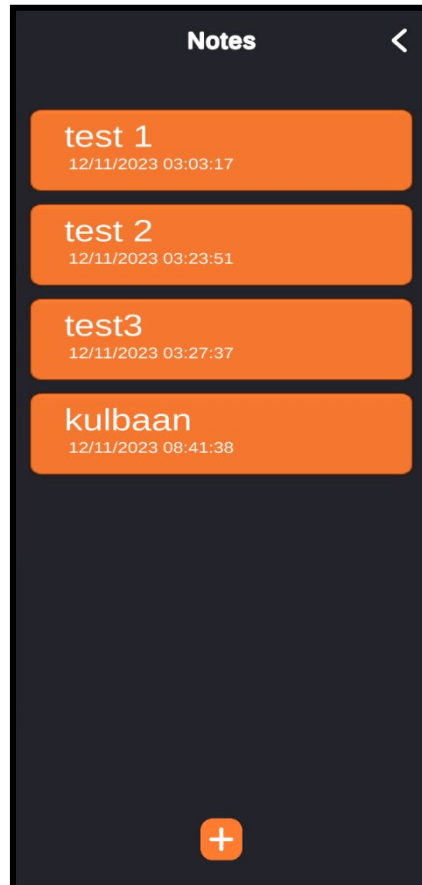
b. List of Created Notes**Figure 13.** View list of created notes

Figure 13 shows the panel where it displays all the notes created by the user as a list.

c. *Edit Created Notes*

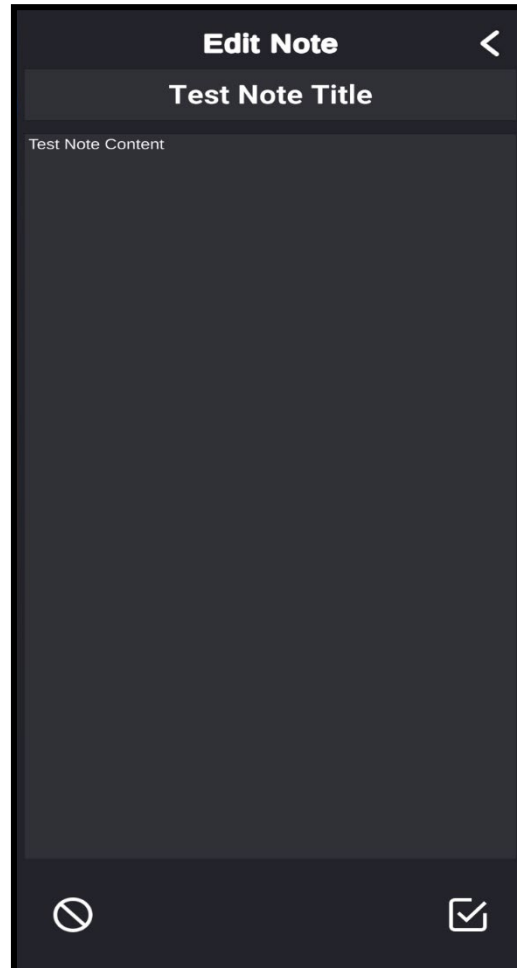


Figure 14. Edit created notes

Figure 14 display another panel for note editing. It shows the title and the content of the note.

d. *View and Delete Created Note*

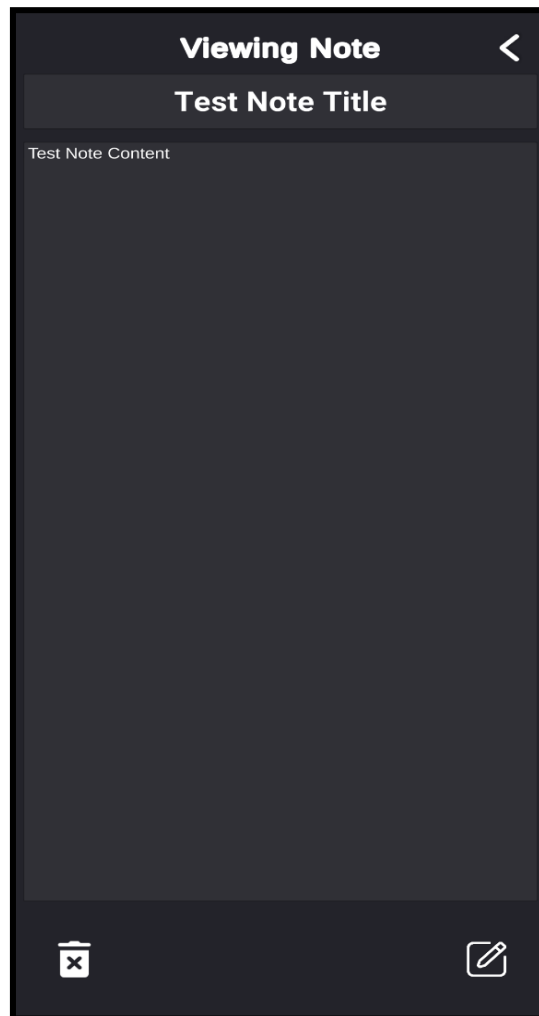


Figure 15. View and Delete created notes

Figure 15 shows the panel for viewing the created note. When a note on the note list, it will show the note as read-only mode. There are also the buttons in the panel for editing and deleting note

II. Augmented Reality

a. *Use Augmented Reality*

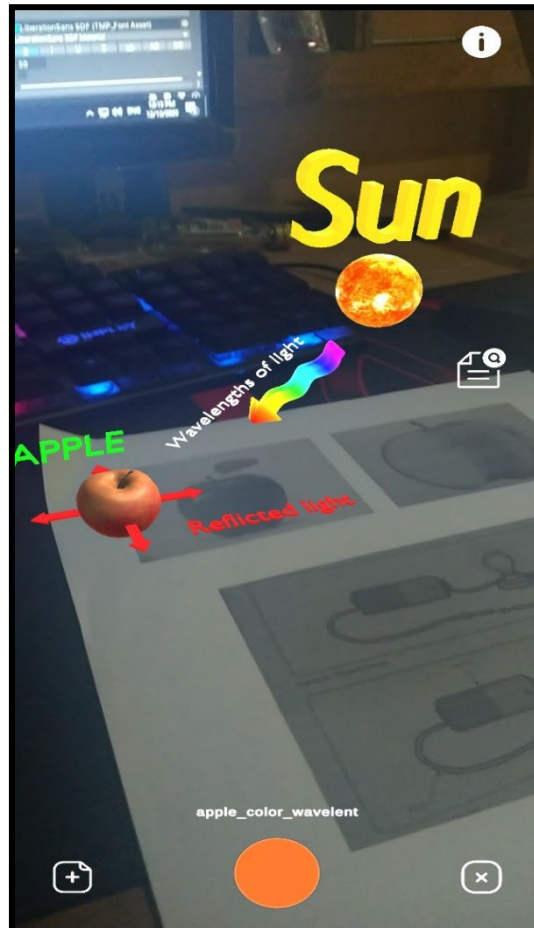


Figure 16. Projecting 3D Model using Augmented Reality

Figure 16 shows the Augmented Reality(AR) feature of the app. It scan images and compare that scanned images that it has then project the 3D Object using Augmented Reality. The Images is pre-loaded thus it only scan what image is already loaded by the system.

b. *3D Model Notes*

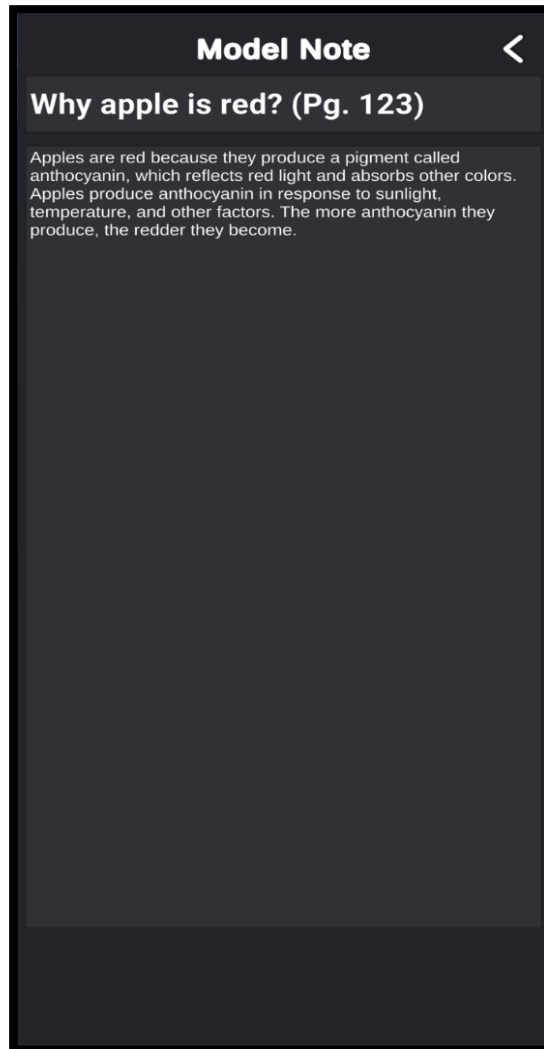


Figure 17. 3D Model Notes

Figure 17 is a note feature for every 3D objects. Means that every 3D Object has it's own static notes to explain what is being shown. The note button only appear on the screen when a 3D Object is being projected then hide when the 3D Object is destroyed.

c. *3D Model List*

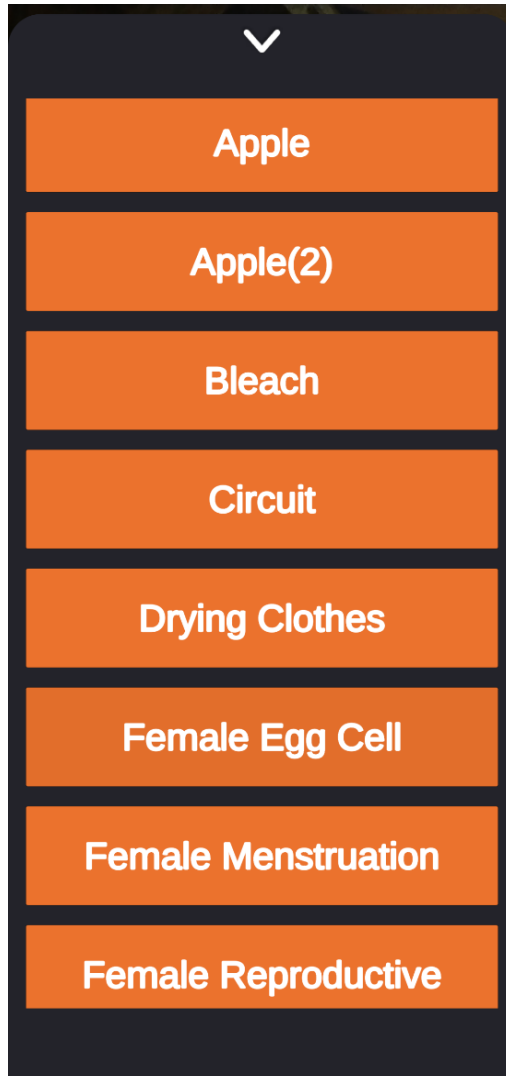


Figure 18. 3D Model List

Figure 18 is a panel for the list of all the 3D Objects the app has. There are currently 17 3D models available.

Objective 2: Evaluate the acceptance level and efficacy of Sci-AR Application

Profile of the Tubod, Elementary School Pupils

The table below presents data gathered from students for the evaluation of Sci-AR: Enhance Science Learning Through Augmented Reality. Out of the respondents, 43.9% were female, and 56.1% were male. All participants belong to the fifth grade, with an average age of 11, constituting 48.8% of the overall sample. This information provides insight into the demographic composition of those who participated in the assessment.

Table 4. Tubod Elementary School Pupils

	FREQUENCY	PERCENTAGE
Gender		
Male	23	56.1%
Female	18	43.9%

Perceived Ease of Use

The table below shows that the respondents generally disagree with the statements, indicating that they find Sci-AR difficult to use. The overall mean score is 2.312, which falls into suggesting that the respondents have a negative attitude towards using Sci-AR.

Table 5. Perceived Ease of Use

Item	Frequency	Interpretation
I feel that using Sci-AR would be easy for me.	2.19	Disagree
I feel that using Sci-AR would be clear and understandable	2.36	Disagree
Learning to operate Sci-AR would be easy to me.	2.46	Disagree
It would be easy for me to become productive at using Sci-AR.	2.48	Disagree
I feel that using Sci-AR would improve my overall performance.	2.07	Disagree
Over-all Mean:		2.312
		Disagree

Legend:

Scale	Interval	Description	Interpretation
5	4.20-5.00	Highly Positive	Strongly Agree
4	3.40-4.19	Positive	Agree
3	2.60-3.39	Neutral	Neutral
2	1.80-2.59	Negative	Disagree
1	1.00-1.79	Highly Negative	Strongly Disagree

Perceived Usefulness

The respondents have a positive attitude towards using Sci-AR for science education, recognizing its potential as a helpful, enabling, and effective tool. They believe it simplifies the learning process and makes it more accessible. The overall mean score of 3.854 is Positive, indicating that Sci-AR would improve learning, enable quicker understanding of science concepts, enhance effectiveness, and make science learning easier.

Table 6. Perceived Usefulness

Item	Frequency	Interpretation
Using Sci-AR would improve my learning.	3.92	Agree
Using Sci-AR would enable me to understand science more quickly.	3.68	Agree
I would find Sci-AR useful in learning and understanding hard-to-get science concepts.	3.90	Agree
Using Sci-AR would enhance my effectiveness.	3.75	Agree
Using Sci-AR would make it easier to learn science.	4.02	Agree

Over-all Mean:	3.854	Agree
-----------------------	--------------	--------------

Legend:

Scale	Interval	Description	Interpretation
5	4.20-5.00	Highly Positive	Strongly Agree
4	3.40-4.19	Positive	Agree
3	2.60-3.39	Neutral	Neutral
2	1.80-.259	Negative	Disagree
1	1.00-1.79	Highly Negative	Strongly Disagree

Attitude toward Using

The survey results indicate a positive attitude towards Sci-AR, with a mean score of 4.014. High mean scores in individual items range from 3.92 to 4.09, indicating positive feelings, anticipation, and intent to use Sci-AR frequently. This indicates a positive to highly positive attitude towards Sci-AR, suggesting its potential as a valuable tool for science education, as respondents perceive it as enjoyable, beneficial, and desirable.

Table 7. Attitude toward Using

Item	Frequency	Interpretation
I like doing my tasks using Sci-AR.	3.95	Agree
I have positive feelings towards using Sci-AR.	4.02	Agree
I look forward to those aspects of my tasks that requires me to use Sci-AR.	4.09	Agree
I think that using Sci-AR is a good idea.	4.09	Agree
I intend to use Sci-AR frequently.	3.92	Agree

Over-all Mean:	4.014	Agree
-----------------------	--------------	--------------

Legend:

Scale	Interval	Description	Interpretation
5	4.20-5.00	Highly Positive	Strongly Agree
4	3.40-4.19	Positive	Agree
3	2.60-3.39	Neutral	Neutral
2	1.80-2.59	Negative	Disagree
1	1.00-1.79	Highly Negative	Strongly Disagree

CHAPTER 5

SUMMARY, CONCLUSION, AND RECOMMENDATION

This chapter provides an overview of the data collected during the study and presents the conclusions drawn from the research. Additionally, it offers recommendations for potential implementation in future research endeavors.

Summary Of Findings

The study yielded positive results, as indicated below:

1. **Out of the respondents, 43.9% were female, and 56.1% were male.**
2. Using the Technology Acceptance Model, indicates positive student receptiveness to Sci-AR for enhanced science learning has mean of 3.4. Respondents' express confidence in its effectiveness, anticipating benefits such as easier comprehension, increased productivity, and enhanced academic performance.

Conclusion

The study concludes with the following conclusions in light of its findings.

Following the evaluation, the majority of respondents approved Sci-AR: Enhance Science Learning Through Augmented Reality. It demonstrates that respondents' attitudes on using Sci-AR: Enhance Science Learning Through Augmented Reality are influenced by how simple and practical they believe the technology to be. This suggests that Sci-AR: Enhance Science Learning Through Augmented Reality has a favorable effect since students' attitudes improve for every perceived utility and ease of usage. Thus, it can be concluded that students benefit from Sci-AR: Enhance Science Learning Through Augmented Reality.

Recommendations

The system suggests the following based on the results and the experiences of the students:

1. **More 3D models to be added.** More 3D models means more contents to explore which help students to learn more.
2. **Text-to-Speech note.** With text-to-speech features it makes the app more convenient for the student to use the app.
3. **More animated 3D models.** Adding more animations means other more ways to shows the information about the topic hence helping the students learn effectively.
4. **Updated contents of 3D Models.** The world is everchanging and so the information so updating 3D models is to insure that the learners will never left behind for new discoveries.

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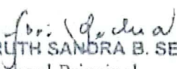
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APPENDICES
Appendix A
Letter of Approval

December 09, 2023


RUTH SANDRA B. SEBIAL
School Principal
Tubod, Elementary School
Tubod, Iligan City

Greetings of Peace and Prosperity!

The researcher is conducting research entitled "Sci-AR: Enhance Science Learning Through Augmented Reality" as course requirements in the degree Bachelor of Science in Computer Science.


In connection with this, may I ask permission from your good office to please allow the researcher to conduct a survey in Tubod, Elementary School, Iligan City to partially fulfill the researchers' thesis paper.

Participation in this research is entirely voluntary, and you have the right to refuse or withdraw consent at any time without any consequences. If you agree to provide access to the requested data, we will take all necessary measures to ensure the security and privacy of the information.

Your favorable response is very much appreciated. Thank you!

Thank you for your time and consideration.

Sincerely,


EDWARD JR. A. CABELLO
Researcher

Noted by:


ROLAN MERYLL B. MONTEBON
Thesis Adviser


MELANNE GAMBE, MSIT
Dean, CCS

Appendix B

Letter to the Respondents

December 09, 2023

Dear Respondents:


Good Day!

The researcher is conducting research entitled "Sci-AR: Enhance Science Learning Through Augmented Reality" as course requirements in the degree Bachelor of Science in Computer Science.

In connection with this, may I ask permission from you to take the survey by answering the survey questionnaire. Data gathered from this questionnaire is important to the researcher thesis.

Please answer the question truthfully and as honest as you can. Be assured however that your answers will be kept confidential.

Participation in this research is entirely voluntary, and you have the right to refuse or withdraw consent at any time without any consequences. If you agree to provide access to the requested data, we will take all necessary measures to ensure the security and privacy of the information.


Your positive response will be of a great help in the conduct of the researcher study. Thank you!

Sincerely,


EDWARD A. CABELLO
Researcher

Noted by:

ROLAN MERYLL B. MONTEBON
Thesis Adviser


MELLANIE GAMBE, MSIT
Dean, CCS

Appendix C
Survey Questionnaire

Adopted From: [aha gikan ang study]

Sci-AR: Enhance Science Learning Through Augmented Reality

NAME: _____

GENDER: Male ☐ Female ☐ Others ☐

Instruction: Check the box below to your corresponding answer.

5 Strongly Disagree	4 Disagree	3 Neutral	2 Agree	1 Strongly Agree
----------------------------------	----------------------	---------------------	-------------------	-------------------------------

Perceived Ease of Use	5	4	3	2	1
1. I feel that using Sci-AR would be easy for me.					
2. I feel that using Sci-AR would be clear and understandable					
3. Learning to operate Sci-AR would be easy to me.					
4. It would be easy for me to learn science at using Sci-AR.					
5. I feel that using Sci-AR would improve my understanding about science.					

Perceived Usefulness	5	4	3	2	1
1. Using Sci-AR would improve my learning.					
2. Using Sci-AR would enable me to understand science concepts more quickly.					
3. I would find Sci-AR useful in learning and understanding hard-to-get science concepts.					
4. Using Sci-AR would enhance my effectiveness.					
5. Using Sci-AR would make it easier to learn science.					

Attitude Towards Using	5	4	3	2	1
1. I like doing my task using Sci-AR.					
2. I have positive feelings towards using Sci-AR.					
3. I look forward to those aspects of my tasks that requires me to use Sci-AR.					
4. I think that using Sci-AR is a good idea.					
5. I intend to use Sci-AR frequently.					

Appendix D

Data Sets

This table represents the general point average of the respondents.

RESPONDENTS	Q1	Q2	Q3	Q4	Q5
1	2	1	1	1	2
2	1	1	4	1	3
3	3	4	4	3	4
4	4	2	3	3	2
5	1	1	4	3	1
6	1	3	1	4	2
7	1	3	4	3	1
8	4	1	4	3	3
9	4	4	2	4	4
10	1	2	4	3	2
11	4	4	4	1	1
12	1	4	1	1	1
13	1	1	1	1	1
14	1	2	2	1	3
15	1	1	4	3	2
16	4	3	4	4	3
17	4	2	1	4	2
18	2	1	2	2	1
19	1	4	2	4	1
20	4	3	4	4	1
21	3	2	2	2	2
22	3	4	4	3	4
23	1	1	1	4	1
24	4	4	4	4	4
25	1	2	1	3	1
26	2	3	2	2	3
27	1	1	4	3	2
28	1	1	1	1	1
29	3	3	3	4	2
30	4	1	1	4	4
31	1	1	1	1	1
32	3	4	3	1	1
33	1	3	2	2	2
34	3	3	3	3	3
35	4	4	1	1	1
36	4	4	1	1	4
37	2	2	2	3	2
38	1	1	4	1	1
39	1	1	1	1	1

40	1	1	1	4	1
41	1	4	3	1	4
MEAN	2.195121951	2.365853659	2.463414634	2.487804878	2.073170732

RESPONDENTS	Q6	Q7	Q8	Q9	Q10
1	5	1	5	1	5
2	5	5	4	3	5
3	4	5	3	4	3
4	1	2	1	1	2
5	5	4	5	3	5
6	5	3	4	5	2
7	3	5	4	3	5
8	4	3	3	3	3
9	3	2	1	5	2
10	5	3	5	4	4
11	5	4	4	5	5
12	4	3	2	4	5
13	5	3	5	4	5
14	1	3	5	1	3
15	3	4	5	4	1
16	5	5	4	4	4
17	4	4	4	4	5
18	5	5	5	5	5
19	1	2	5	4	3
20	5	4	4	5	5
21	4	3	4	4	3
22	3	3	3	3	3
23	5	5	5	5	5
24	4	4	4	4	4
25	5	3	5	5	5
26	4	3	4	4	3
27	4	3	5	4	5
28	3	5	5	2	5
29	3	4	4	3	4
30	4	4	3	3	5
31	4	4	4	5	5
32	4	5	4	3	4
33	2	1	3	4	5
34	4	4	3	4	3
35	4	5	4	5	4
36	4	5	4	4	4
37	5	3	2	3	4
38	5	4	3	4	5
39	4	4	4	4	4

40	5	4	5	4	5
41	3	5	4	5	3
MEAN	3.926829268	3.682926829	3.902439024	3.756097561	4.024390244

RESPONDENTS	Q11	Q12	Q13	Q14	Q15
1	5	5	5	5	5
2	4	2	5	4	5
3	3	3	4	3	4
4	1	1	1	1	1
5	5	3	5	4	5
6	2	3	5	4	2
7	4	5	5	3	4
8	3	3	5	5	5
9	5	3	1	5	3
10	5	5	2	5	1
11	4	4	5	4	5
12	3	3	4	4	3
13	5	4	5	5	3
14	3	5	1	3	4
15	4	4	5	4	5
16	5	5	5	5	5
17	5	5	5	4	4
18	5	5	5	5	5
19	5	4	5	2	3
20	5	4	5	5	5
21	3	4	3	3	4
22	4	4	3	4	3
23	5	4	5	5	5
24	5	5	5	4	4
25	5	4	5	2	5
26	3	4	4	4	3
27	3	4	4	5	5
28	5	5	5	4	5
29	4	4	3	5	3
30	3	4	4	5	3
31	4	4	5	5	4
32	3	4	4	5	4
33	2	3	4	2	3
34	3	4	4	4	3
35	4	5	4	5	5
36	5	5	5	5	5
37	5	3	4	4	2
38	4	4	3	4	4
39	4	5	5	5	4

40	4	5	3	4	5
41	4	5	3	4	5
MEAN	3.9756097 56	4.0243902 44	4.0975609 76	4.0975609 76	3.9268292 68

MEAN	
Q1	2.195122
Q2	2.365854
Q3	2.463415
Q4	2.487805
Q5	2.073171
Q6	3.926829
Q7	3.682927
Q8	3.902439
Q9	3.756098
Q10	4.02439
Q11	3.97561
Q12	4.02439
Q13	4.097561
Q14	4.097561
Q15	3.926829
OVERALL MEAN	3.4

Appendix E
Photo Documentation



Figure 19. Respondents trying out Sci-AR



Figure 20. The researcher (Left) with the student's teacher (Right)

CURRICULUM VITA

PERSONAL INFORMATION

Name: Edward Jr A. Cabello

Address: Purok 5 Saray, Iligan City



Age: 23 Years Old

Gender: Male

Height: 179cm

Weight: 52kg

Father's Name: Eduardo M. Cabello Sr.

Mother's name: Nida A. Cabello

Educational Background:

College: St. Peter's College

Highschool: Iligan City National High School

Elementary: North I Central School

Certificate of Editing and Proofreading

Certificate of Editing and Proofreading

Certificate of Statistical Analysis

Grammarly and Plagiarism Certification

CERTIFICATE OF AUTHENTIC AUTHORSHIP

We hereby declare that this submission is our own work and to the best of our knowledge, it contains no materials previously published or written by another person, nor material which, to a substantial extent, has been accepted for the award of any degree or diploma at SPC or any other educational constitution, except where due acknowledgment is made in the manuscript. Any contribution made to the research by others, with whom we have worked at St. Peter's College or elsewhere, is explicitly acknowledged in the manuscript.

We also declare that the intellectual content of this manuscript is the product of our own work, except for the assistance that we received in this thesis' design and conception, or in style, presentation and linguistic expression is acknowledged.

Edward Jr A. Cabello
Researcher

SUBSCRIBED AND SWORN TO before me this _____ day of _____, 2024,
affiant exhibited his/her _____ issued on
_____, at _____.