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SCI-AR: ENHANCE SCIENCE LEARNING THROUGH AUGMENTED REALITY

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Abstract: **This research work is focused on development of a mobile augmented reality application, for use in helping kids with learning problem in science class. Science per se has inherent features that are abstract in nature, thus complicating the processes of learning and at the same time giving a negative outlook towards science. In this regard, the application has the use of graphics and symbols combining with the use of AR that enhances understanding and leads to involvement of students. It can be on Android OS for mobile phones with Unity3D and ARFoundation/ARCore as the development tools. Acceptance of consumer Credit has used the Technology Acceptance Model for developing its theoretical modelling of prediction. In making the system, the development model of Agile Methodology Model has been adopted. This study tries to apply a new approach that enhances the learners' motivation and confidence in science learning without pre-empting any other teaching strategy. As for the application of a mobile and graphically augmented reality, it raises a lot of potential for improvement of science learning for children with certain learning difficulties in this new, interactive type of format.**

Keywords: **Augmented Reality, Mobile Application, Science Learning, Specific Learning Difficulties, Unity3D, AR Foundation, ARCore, Android, Technology Acceptance Model, Agile Methodology, Interactive Learning, Immersive Learning Experience.**

I. INTRODUCTION

As far as it relies on abstract notions and as far as it is highly cognitive the problem for students with specific learning difficulties is to understand that science is problematic; it is also problematic for students who do not have specific learning difficulties. Likewise, normally, a learning point of debate in school is the exerting of full understanding on concepts often difficult and abstract as are presented in the basic mechanics of astronomy. The elements associated with the above-discussed concepts make it impossible to understand these; hence preventing the formation of individual attitudes towards the subject in total (Sahin & Yilmaz, 2020; Turan & Atila, 2021).

Sahin and Yilmaz (2020) further noted that concerning these issues, the use of the visual helpers inside the class to explain those kinds of problems affecting the understanding of students in those abstract conceptions in science might be enhanced. Further, AR is relatively a new concept integrated in education faculty but is evidently has great potentiality in the upcoming days. Augmented Reality is a new technology which several learning environments have adopted (Jessup et al., 2019). Also, Liono et al. (2020) concluded that one of the most effective forms of instructions is the visual one as it elevates the level of students' engagement and helps them grasp the concept even better.

The upcoming application is set to run, on the Android operating system specifically designed for versions that support augmented reality capabilities. To achieve this the researcher is utilizing Unity3D along with ARFoundation and ARCore to develop a mobile app. Unity3D is a versatile game engine that allows for the creation of video games across platforms including computers, consoles and mobile devices. It encompasses tasks such as designing 3D graphics implementing physics creating animations and building user interfaces. The ARFoundation/ARCore framework provided by Google is specifically used for crafting reality experiences on devices. By leveraging sensors and SLAM algorithms these devices can comprehend their surroundings and superimpose digital content onto the real world as users perceive it. This article explores an innovative approach focused on enhancing student motivation and confidence, in science while maintaining traditional teaching methods.

The project aims to create an app that uses reality to enhance science education by actively involving students in grasping scientific concepts. The researcher is concentrating on developing this mobile app incorporating features outlined earlier in the research. Additionally, they plan to overlay 3D models or objects in the augmented environment using AR Foundation or AR Core technology.

This information will be relevant, to those interested in the systems potential future applications particularly students. It offers advantages for students by improving their learning process and comprehension of scientific concepts. Future researchers will undoubtedly find value in the system utilized in this study as it aids student learning and also acts as a repository for ideas that can be applied in related research endeavors.

Figures 1, 5 illustrate the workflow of the AR App. The intricate interplay between the device Unity3D Engine and ARCore SDK overlays reality. Whenever an image is scanned a 3D model is projected enhancing engagement and interactivity. Moreover, the mobile application allows users to note down relevant items and later revise or delete those notes.

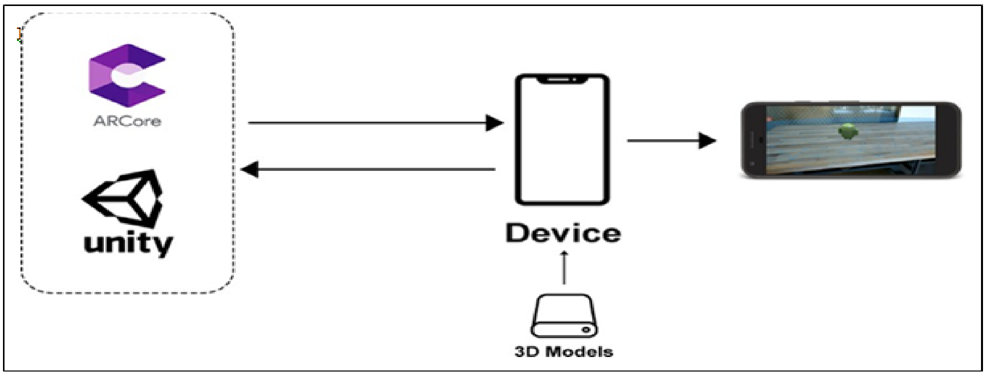

Figure 1. Augmented Reality Workflow Diagram

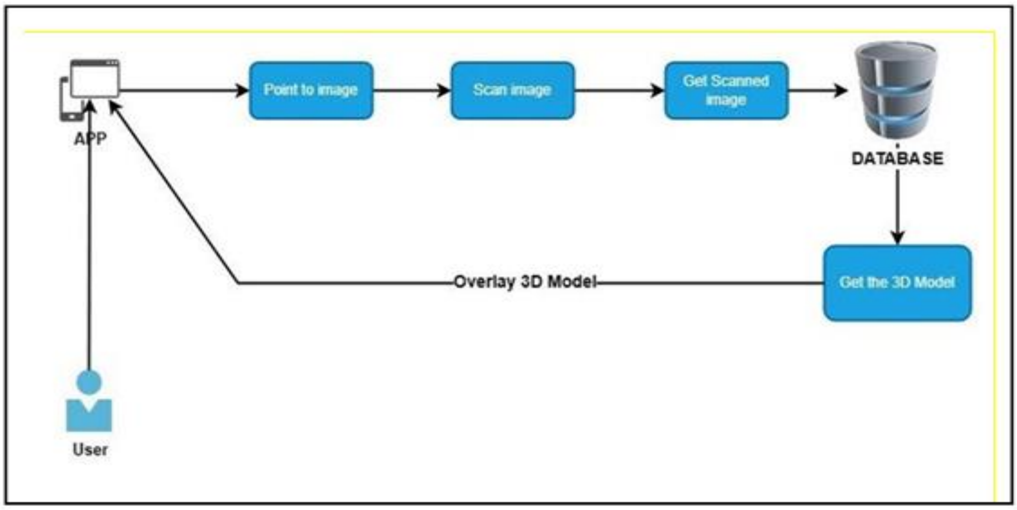

Figure 2. Sci-AR – Getting a 3D Model from the database

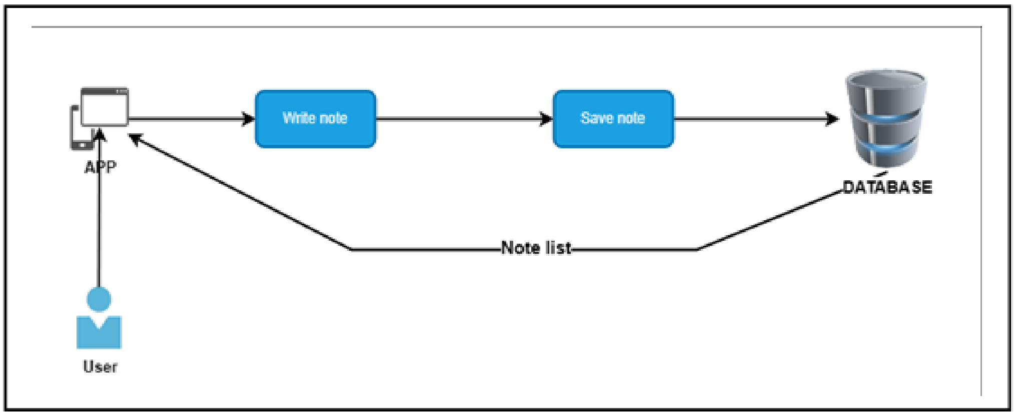

Figure 3. Sci-AR – Creating/Writing

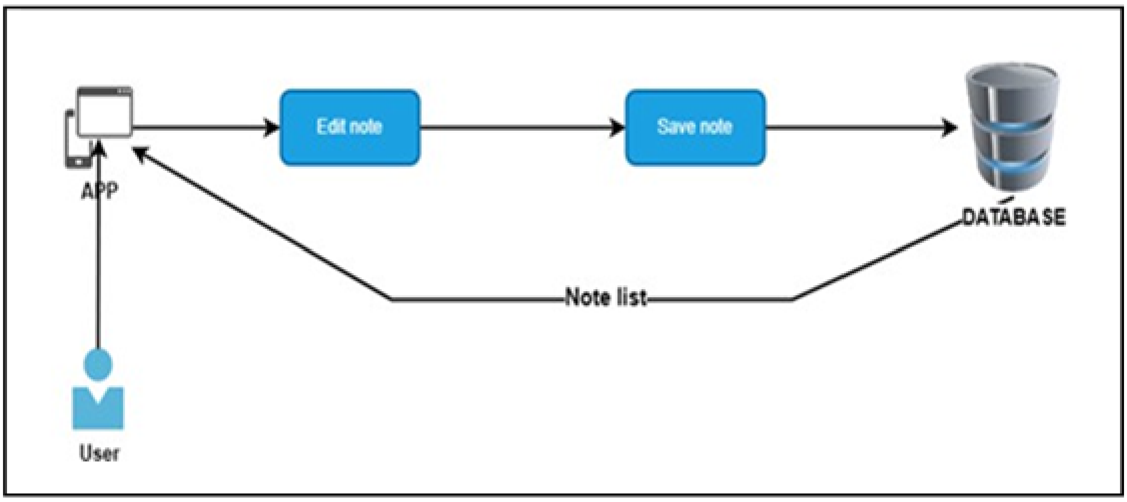

Figure 4. Sci-AR – Editing existing notes

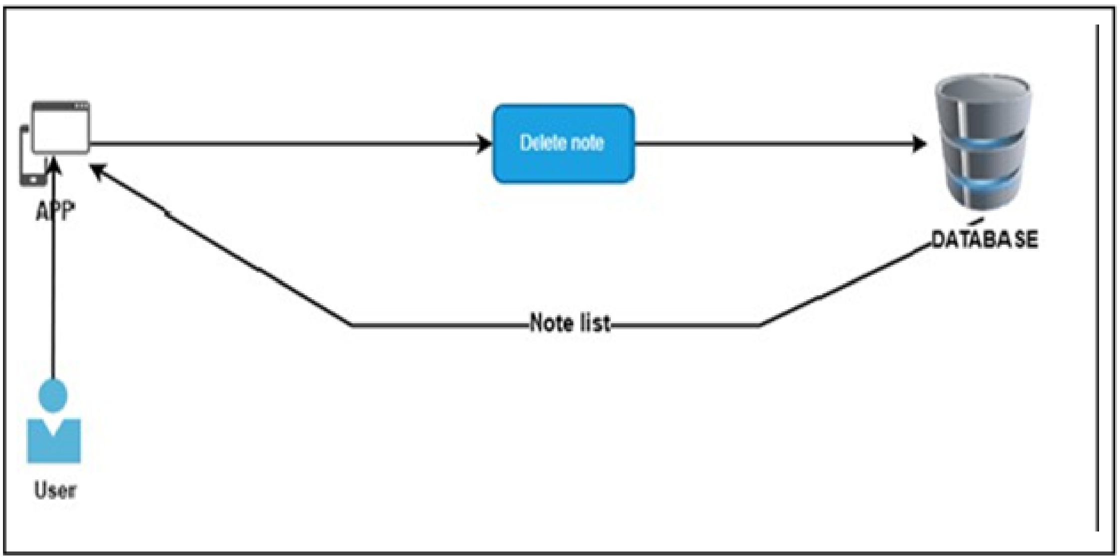

Figure 5. Sci-AR – Deleting existing notes

II. LITERATURE REVIEW

The studies and literature in this chapter provided background and theory relevant to the proposed study.

2.1 Augmented Reality

As time flies by the historical information necessary to educate generations evolves based on the context in which it is presented both in terms of time and location. This leads to challenges in preserving history.

Web archiving which involves collecting online content and preserving it for the future has been one approach to tackling the issue of preservation.

Over the past 20 years the integration of technology into institutions has transformed how knowledge is delivered to students. Indeed, various advancements have been made with a focus on enhancing teaching and learning effectiveness by combining technology with effective pedagogical methods. A notable example of this technological integration is found in reality.

This technological phenomenon, more popularly known as AR, superimposes digital information on the real world in order to create an interactive experience with the environment. As its name suggests, "augmented" in augmented reality refers to the enhancement in the way anything else is added to make it richer. It means the enhancement of the physical world through the infusion of digital elements at the same time layered over actual things or the environment, for that matter. These can involve audio, graphics, many other types of sensor inputs. This combination of virtual and physical worlds enables interaction. Besides that, augmented reality makes use of two different tracking approaches: marker-based and markerless. Marker-based tracking makes use of black-and-white markers with a-highly-contrasting black border on a white background.

On the other hand, markerless tracking demonstrates compatibility with markers of any kind. Indeed, paper-based media best work with marker-based tracking as they enable the user to view interacting 3D objects located immediately above the marker on the page. Users are capable of interacting with the augmented content by changing the paper and sliding it along with the marker (Andrea et al., 2019).

As reported by Gimeno and Cabero-Almenara, in the year 2019, saw the blooms raising up with AR technology and began to exert its power in the education sector. Following mobile technology, augmented reality has been rated as the next best way to have the implementation of the processes for learning, which is considerably deep and meaningful.

In more general terms, AR has the potential to change how learning content is shared with students, from state-of-the-art undergraduate and graduate education to leading-edge public outreach and involvement. Most interestingly, since it is vitally important as a pedagogical tool, AR could function in a blended learning environment linking a course of study, a virtual/physical mixture, or a combination of both kinds of artifacts (Barrow et al., 2019). This can lead to increasing students' motivation toward learning and ultimately improving academic achievement (Khan et al., 2019). Because it can display information in 3D virtual, the user is encouraged to interact with it, and so has a better user experience (Majeed & Ali, 2020).

Similarly, Sahin and Yilmaz (2020) established that Augmented Reality is necessary for the concreting of abstract ideas regarding the stage of development of the student, and also to observe the processes and objects which are impossible to meet in reality.

2.2 Technology Acceptance Model (TAM) Theory

The Technology Acceptance Model represents a theoretical model describing how and why users adopt technological innovations within the setting of information systems. Any application of a system in actual reality is just another way of using technology. The purposes differ from each other, but with every use of technology, there are behavioral aspects concerned.

The TAM and its extensions represent necessary theoretical tools for the forecasting of user behavior and have crossed boundaries of application across contexts, disciplines, and regions.

Major factors determining an individual's tendency to accept new technology have been perceived ease of use and perceived utility, so the TAM had become a model of choice with regard to the acceptance of technology. This also is in use in a multitude of areas, among which are business, medicine, and education.

In 1986, the Technology Adoption Methodology (TAM) was first proposed by Fred Davis and further detailed by López et al. in 2019. It shows how beliefs affect technology implementation, including those users' behaviors related to their perceived value and ease of use.

According to Jang et al. (2021), various theoretical models were proposed to explain the process of technology adoption, including the Theory of Reasoned Action, the Technology Acceptance Model, and the Unified Theory of Acceptance and Use of Technology. Among these models, the TAM is the most widely implemented and has been applied in many studies to explain technology acceptance.

In general, the TAM was highly saluted as a relatively valid predictor of technology adoption for teachers and a descriptive model to explain how teachers perceived adopting technology.

2.3 Simultaneous Localization and Mapping (SLAM) Algorithm

Simultaneous localization and mapping or SLAM in computer vision and robotics is employed to construct or simultaneously build a map of an unknown environment while localizing an agent. To introduce the items in the virtual environment, there can be a use of Improved SLAM techniques based on structures and the position of an observation point. In a similar manner, Singandhupe and La (2020) provided remarks to define Simultaneous Localization and Mapping (SLAM) as the technique whereby a robot or the sensor system continually identifies the position and environment of the surrounding with the application of sensors.

For instance, Liu et al. (2019) pointed out that registration technology tracking is crucial for registration of real and abstract AR environments. The tracking registration method should stably and quickly pursue a moving subject robustly and in real-time, which is challenging since mobile AR involves erratic camera movements. Additionally, Tang and Cao (2020) noted that AR technology requires attention to three primary aspects: It is considered to be the key for truly 3D registration, authenticity in VR fusion, and natural human-PC interfaces. Among these aspects, 3D registration is more important as it has a key role in creating the realistic illusion of merging the virtual environment. Hence, the fundamental method of 3D registration is Simultaneous Localization and Mapping (SLAM), which can locate the device in the unknown environment in real-time (Li et al., 2019).

In addition, using the Google ARCore tools Android developers can build the Augmented Reality applications for Android smart phones. To understand the environment and place virtual objects on top of the physical environment it incorporates the camera, sensors and the motion processors found in the device. In general, SLAM helps to create an accurate and stable augmented reality through the help of ARCore.

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Altogether, using Augmented Reality (AR) becomes a progressive technology that can inculcate the peculiar learning experience to students and teachers in science education. Improved motivation, improved understanding, as well as improved level of interactivity are some of the benefits of augmented reality in a classroom setting
.

III. MATERIALS AND METHODS/ METHODOLOGY

The researcher used the following methods and procedures to support the design and construction of the proposed system.

3.1 Research Setting

The study was carried out in Tubod Elementary School in Iligan City, Lanao del Norte, during the 2022–2023 academic year. The majority of the system's users were students in grade 5. They were the initial respondents who answered the survey questionnaire.

3.2 Research Design

Throughout the software development process, the Agile Methodology Model fosters collaboration, iteration, and adaptation (Rachmawati et al., 2021).
Furthermore, as per Kaliparambil (2022), the Agile methodology-based mobile app development process is highly flexible, allowing the researcher to tailor the timeframe according to certain needs and preferences. This method allows for flexibility in the organization of software and mobile app development projects while prioritizing small, gradual changes.

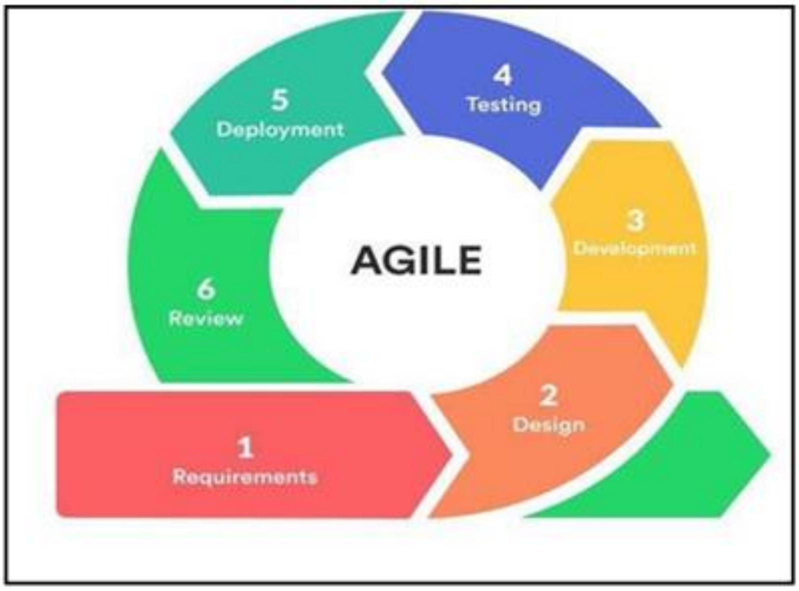

Figure 6. Agile Methodology

The proposed system was developed using the Agile Methodology Model, shown in Figure 6. Also, Waterfall is comprised of six distinct phases. These are:

Phase 1: Requirements Phase
In this phase, project specifications are established to meet the project scope definition, some key activities, and major/critical deliverables are discussed with the client. They will remain probably as few as possible and could be added later on if needed.

Phase 2: Design Phase
To meet the need mentioned in the previous phase, during this phase an assessment will be made of the need for adequate database models, business rules and technology such as languages, data layer, services, etc.

Phase 3: Development and Coding Phase
Once the planning and the analysis phases have been completed, it is time to go ahead and code or implement what has been planned. This setup of the site will incorporate all the planning, specification and design documents that have been worked up to this phase of this project.

Phase 4: Integration and Testing Phase
Once the current build iteration has been coded and implemented, the next procedure is to perform a number of tests run in order to detect or trace for possible defects that has occurred.

Phase 5: Implementation and Deployment Phase
The system is now ready to be installed and used in practice after various tests have been conducted.

Phase 6: Review Phase
Once the system is live, then it will then be evaluated to see what further modifications are required prior to the next release.

3.3 Physical Environment and Resources
This section presented the Learning Management System hardware and software specifications.

Hardware Requirements
Mobile Device (Android):

- The most widely accepted version of Android to date is Android 8.1 Oreo. It is polished, feature-rich, clean, and visually consistent.
- With eight Kryo 260 cores, the Qualcomm Snapdragon 636 is an octa-core processor with a maximum clock frequency of 1.8 GHz. Performance-wise, the Kryo 260 Cores beat the SD 630's ARM Cortex-A53 Cores by 40%. Additionally, the MediaTek Helio G35 chip uses an octa-core processor constructed using a 12nm architecture. Nevertheless, it only has Cortex-A53 cores rather than the quicker A55 or A7x CPUs. Up to 6GB of LPDDR4x RAM, with a frequency of 1,600MHz, can be supported by the processor, which operates at 2.3GHz. Additionally, the chip can support less expensive LPDDR3 memory up to a maximum of 4GB in capacity.
- Web browsing, social media, video streaming, and several well-known mobile games require at least 4GB of RAM, while the exact amount needed varies according on the programs you use (Phillips, 2022). In addition, a gigabyte (GB) is the unit of measurement for digital data, equal to one billion bytes. It alludes to a computer file or software's capacity to hold one billion bytes.
- With 64GB, you will have enough if you use your phone for WhatsApp and calls. In addition, you have space for some social media apps and light games.
- For chipsets from MediaTek and Snapdragon, the graphics card should be GE8320 or later, capable of supporting augmented reality (AR). A chipset is an interconnected group of motherboard chips or integrated circuits that control the flow of information and commands between the central processing unit (CPU) and external devices. The majority of computing machines have a graphics card, also known as a video card or display adapter, which is in charge of rendering graphical data with excellent clarity, definition, color, and overall visual quality.
- The Camera must at least be 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 Requirements
In terms of software, these are the things that are recommender according to online searches gathered by the researcher.

- Microsoft designed the object-oriented, type-safe, and contemporary programming language known as C# (pronounced "See Sharp"). Developers can create a wide range of applications with C#, including database applications, Web services, Windows client apps, and more.
- A cross-platform game engine called Unity3D is used to create interactive stories, simulations, and 2D and 3D games. It will be employed in the creation of the augmented reality mobile application.
- Google created the ARCore software development kit (SDK), which makes it possible to create augmented reality (AR) experiences on Android smartphones. 3D objects will be projected onto the real world using it. The Simultaneous Localization and Mapping (SLAM) algorithm is used by ARCore to map the surroundings and position virtual items in the physical world.
- One software library that offers a relational database management system is called SQLite. It is intended to function as a serverless, transactional, SQL database engine that is self-contained. Because SQLite is incorporated into so many operating systems, browsers, mobile devices, and other software products, it is one of the most commonly used databases in the world.

3.4 Tools and Techniques Used in the Study
This section presented the tools and techniques, including the Use Case Diagram, Sequence Diagram, and Activity Diagram to picture the entire system.

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.

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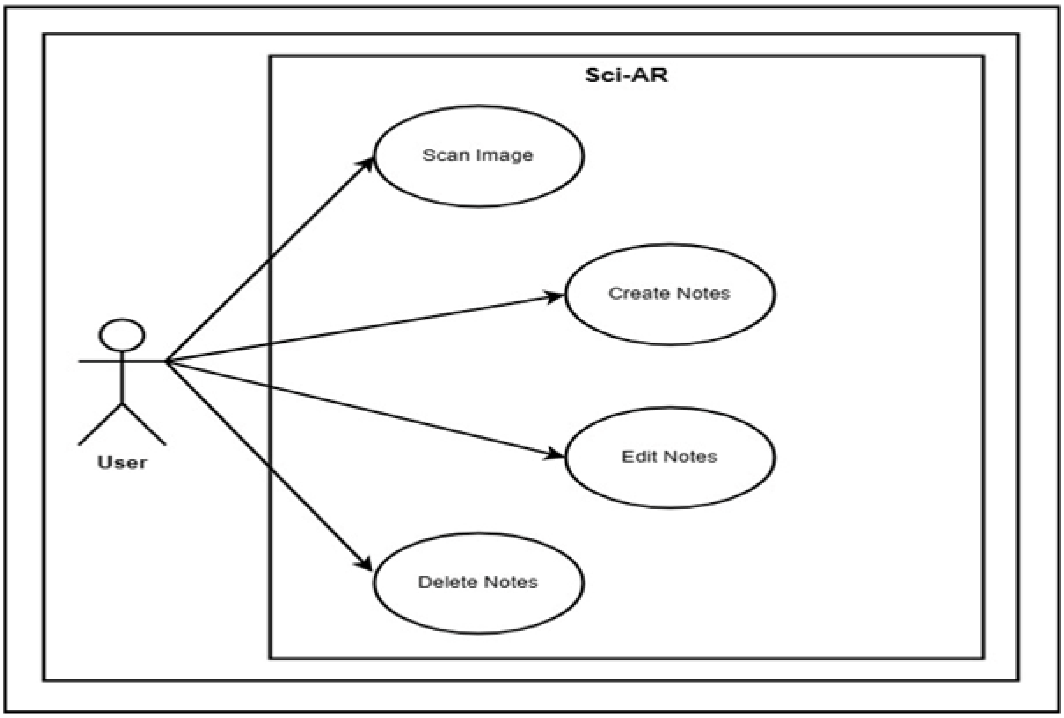

Figure 7. Use Case Diagram

According to the Figure 7, a use case describes how the specific user of the process or system in question will accomplish a given goal. In other words, the user may grapple with the augmented reality together with the science book of adherent. Moreover, a note can also be created by the user to write down and store some information which may also be modified or deleted afterwards.

Sequence Diagram

Sequence diagram depicts the flow of interactions between an object and other objects in a particular system with reference to the order of the flow. The builders and business analysts utilize them primarily for the comprehension of a project's necessities. These diagrams explain how various elements of the system communicate with each other as well as the flow of such interactions.

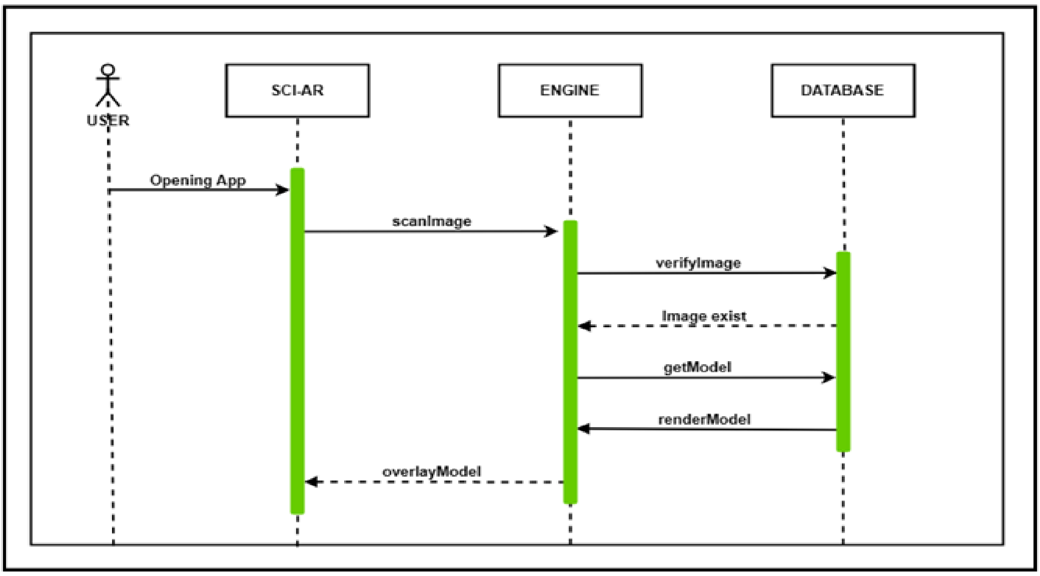

Figure 8. Sequence Diagram

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Figure 8. also provides information on the sequence diagram for the application. The moment that the user opens the program, a camera like user interface just pops out right from the start. Then the user is able to point at any image in the book with the app, in which the scanImage and verifyImage functions scan the image and check whether the image is in the database or not. Next, it will check its presence and then the program will use the getModel function to get the correct 3D model and then place it on the real environment.

Activity Diagram
Activity diagram is one of the behavioral modeling techniques, which is used to depict the flow of a specific and important activity. It focuses on the calls and their preconditions for execution or the sequence of activities in terms of their execution. The state of an activity is related to the performing of each step of the Work flow.

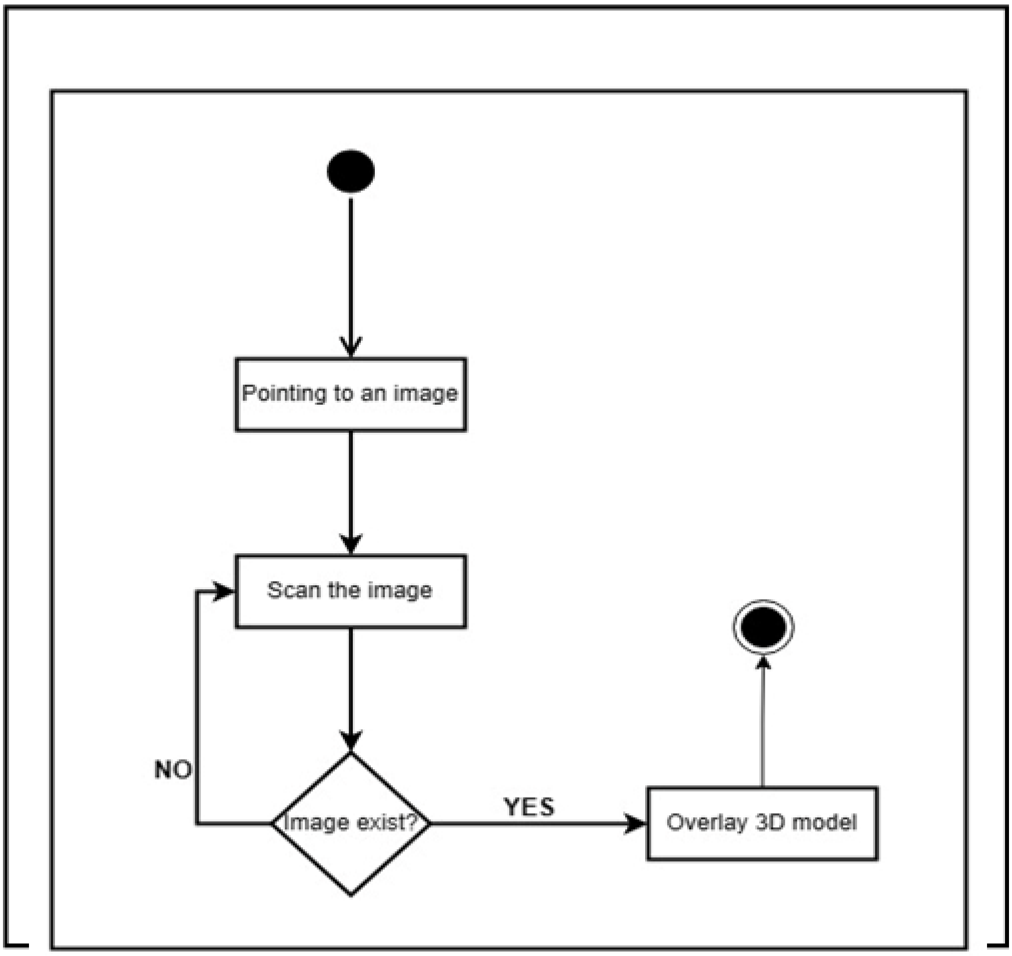

Figure 9. Activity Diagram

Figure 9. The article also provides a clear, approximate model of how the system works. Firstly, the user will be taken to a screen with an appearance similar to a conventional camera where they will be able to highlight to an image in the book. The application will then parse the image while comparing it to the saved images for AR in the database which also has its corresponding 3D model. After this confirmation, the app will then take a corresponding 3D model and then place it in the real environment.

3.5. Participants and Sampling Procedure
The researcher used participants in form of Grade 5 students from Tubod Elementary School in Iligan City. The researcher was able to get a total of forty (40) respondents for the study. Consistent with the framework of this research, the developed questionnaire is divided into three sections which correspond to the components of the TAM theory and all are well-designed to cater for parts that are relevant to this research.

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IV. RESULTS AND DISCUSSION

This chapter discusses the project implementation, reveals the study results and gives an overview of the system assessment. Also, it presents the design of the system and the results from the set questionnaires filled by the respondents.

4.1 Final Product

Figure 10 below shows the Augmented Reality (AR) feature of the app. It scans 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 scans what image is already loaded by the system.

Figure 10. Projecting 3D Model using Augmented Reality

The Figure 11 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.

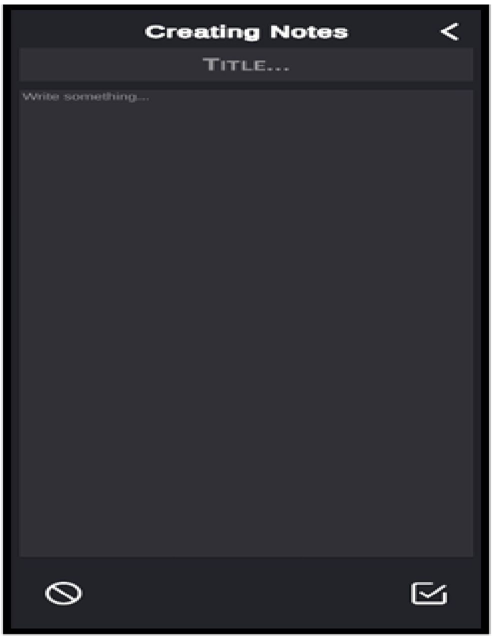

Figure 11. Note creation

The Figure 12 below shows the panel where it list all the notes created.

Figure 12. View list of created notes

The Figure 13 display another panel for note editing. It shows the title and the content of the note.

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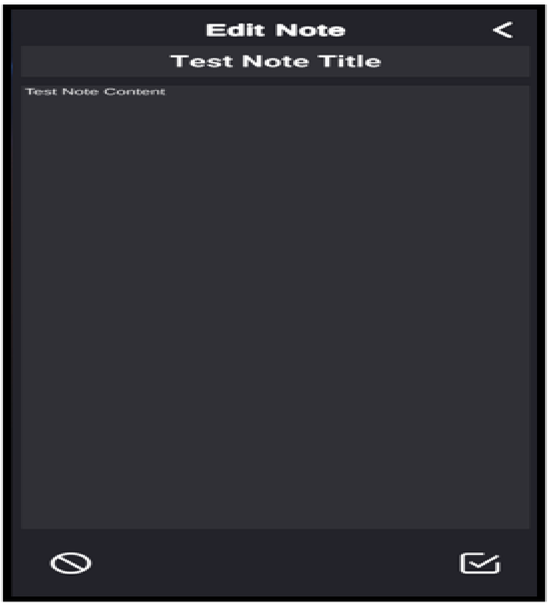

Figure 13. Edit created notes.

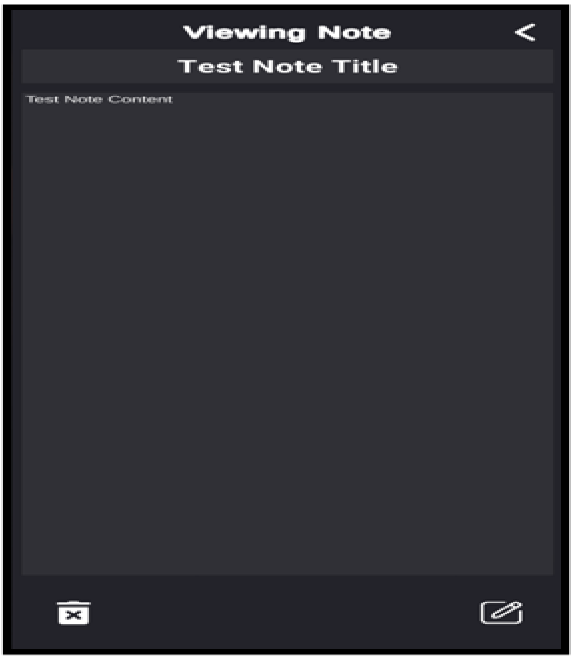

Figure 14. View and delete created notes

Figure 14 below 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.

Objective 2: Evaluating the acceptance level and efficacy of Sci-AR Application by Grade 5 Students.

Table 1: Respondents' Demographic Data

Character		Frequency	Percent
Gender	Male	23	51.6%
	Female	18	43.9%

The table above shows the surveyed Grade 5 students' demographic such as their gender. With this, the author will know the references of students on applications based on these factors.

Table 2: Data for Sci-AR: Enhance Science Learning Through Augmented Reality Mobile App adoption using TAM theory.

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 Ease of Use

The table 2 above shows that the respondents generally disagree with the statements, indicating that they find Sci-AR challenging. The overall mean score is 2.312, which suggests the respondents have a negative attitude toward using Sci-AR.

Perceived Usefulness

Item	**Frequency**	**Interpretation**
Using Sci-AR improve my productivity	3.92	Agree
Using Sci-AR would enable me to accomplish tasks more quickly.	3.68	Agree
I would find Sci-AR useful in completing my tasks.	3.90	Agree
Using Sci-AR would enhance my effectiveness.	3.75	Agree
Using Sci-AR would make it easier to complete my task.	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	1.80-2.59	Negative	Disagree
1	1.00-1.79	Highly Negative	Strongly Disagree

Perceived Usefulness
The table above shows that 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.

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-.259	Negative	Disagree
1	1.00-1.79	Highly Negative	Strongly Disagree

Attitude toward Using
The number obtained from the survey is a mean and it is equal to 4. Again, only '<st>014' these respondents have a positive attitude about sci-AR. The various items have high mean scores the mean scores range from 3. 92 to 4. 09, which are positive emotions, expectation and desire when using Sci-AR more often. From the results presented above, the following can be concluded: Respondents have positive attitude toward Sci-AR as they regard it as a source of fun, benefit and gain.

V. CONCLUSION

The following concluding have been made on the basis of this study: Most respondents approved Sci-AR: Implement Augmented Reality in Order to Improve the Results of Science Classes after the evaluation. It demonstrates that respondents' attitudes on using Sci-AR: Perceived ease of the technology that students have towards the Enhance Science Learning Through Augmented Reality is determined by how easy they perceive the same technology to be. This suggests that Sci-AR: Since for every perceived utility and easiness of use, students' attitude towards science increases, the impact of Enhance Science Learning Through Augmented Reality is favorable. Thus, students benefit from

Sci-AR: How to make learning of science more engaging through enhanced augmented reality.

Ethical Approval

The plans for this study were reviewed and approved by the Office of Research in December of 2023 as well as the Dean of Computer Studies. Further, they were given permits by the President of St. Peter's College, Iligan City to administer survey questionnaires to the Tubod Elementary School – grade 5 students. In the study, all participants received written informed consent for the use of the data and the dissemination of the data while at the same time protecting the participants' identity.

Data Availability

Underlying data

Figshare: Sci-AR: Enhance Science Learning Through Augmented Reality
https://doi.org/10.6084/m9.figshare. 24130041

This project contains the raw data for evaluating the desktop application by the students.
- Raw-data.xls

Extended data

Figshare: Sci-AR: Enhance Science Learning Through Augmented Reality
https://doi.org/10.6084/m9.figshare.24130041

The project contains extended data.
- Questionnaire.docx

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