Math-Wonders: Augmented Reality Flashcards Using Image Recognition Algorithm for Enhanced Children's Learning

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Endorsement Letter

This Computer Science Thesis entitled **"Math-Wonders: Augmented Reality Flashcards using Image Recognition Algorithm for Enhanced Children's Learning"** prepared by John Emmanuel E. Tayam, Raymond Irhan F. Grimaldo, Luke Aldrin V. Mendoza, and Juan Alfonso S. Mollida in partial fulfillment of the requirements for the degree Bachelor of Science in Computer Science, has been examined and now recommend for Oral Examination.

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Approval Sheet

This is to certify that the CS Thesis project entitled **"Math-Wonders: Augmented Reality Flashcards using Image Recognition Algorithm for Enhanced Children's Learning"** prepared and submitted by John Emmanuel E. Tayam, Raymond Irhan F. Grimaldo, Luke Aldrin V. Mendoza, and Juan Alfonso S. Mollida of BSCS 4Y1-1, has successfully passed the oral examination on December 9, 2024.

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Certificate of Originality

We hereby affirm that this research paper, referred to as the thesis project, is solely our work. We, the researchers, assure that to the best of our knowledge and belief, it does not incorporate any previously published or written material from any other person, nor does it include substantial content that has been accepted for the reward of any other university degree, or diploma, except where proper acknowledgment is provided in the text.

We declare that the ideas and concepts presented in this thesis are the result of our independent efforts, even though we may have received assistance from others in terms of style, presentation, and language usage.

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Dedication

We dedicated our thesis paper first to the God Almighty; his presence guides us and provides inspiration and guidance. We express our heartfelt gratitude for the abundant blessings that have been provided to us throughout this research journey. Our faith in God is the bond, providing us with strength and purpose in our academic pursuits. Through His wisdom, we have found resilience in overcoming challenges and a deeper meaning in our research endeavors.

We are also thankful to all the individuals who have supported our research in participation, recommendation, and encouragement. Their contribution has significantly improved the quality and impact of our work. We are humbled by their willingness to be part of our research and appreciate their belief in the importance of scientific exploration. This dedication is a reflection of the collective effort and shared enthusiasm that has propelled us forward. We are grateful for the opportunity to contribute to our field alongside such dedicated individuals.

-John Emmanuel, Luke Aldrin, Raymond Irhan, and Juan Alfonso

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-John Emmanuel, Luke Aldrin, Raymond Irhan, and Juan Alfonso

Abstract

Mathematics is one of the part of academics, that learners may find simple yet complex at the same time. The research study entitled ‘Math-Wonders: Augmented Reality Flashcards Using Image Recognition Algorithm for Enhanced Children's Learning’, aims to enable young minds to help learn mathematics in a fun and intriguing way. The research will be recognized by Tagalag Elementary School in Valenzuela City as the main beneficiary for the study. The target respondents for the study are a total of 32 grade 2 students who are currently enrolled in the target school, a total of 2 mathematics teacher, and 1 mathematics coordinator. 5 IT-Experts will be welcomed to evaluate the application. In research design, the researchers would use Quantitative method in the Descriptive Quantitative Design approach. For sampling, they will employ purposive sampling to select participants who can provide specific insights into the study's objectives. In data gathering, the researchers have an authorized letter and informed consent form stating to conduct the study. The methodology used is the Agile Method. The research study used Alpha and Beta testing. Alpha testing is exclusive to IT-Experts, Math Coordinator, and Math Teachers, beta testing is exclusive to the end-users (respondents), and the evaluation would be based on ISO 25010 or the Software Product Quality. The evaluation approached using the ISO 25010 product quality model as it had a rating of 4.59; the rating was interpreted as “Highly Acceptable”. Usability received the highest rating of 4.61, interpreted as “Highly Acceptable”. The Efficiency rate is 4.61, interpreted as “Highly Acceptable”. Reliability and Portability both have a rating of 4.59, interpreted as “Highly Acceptable”. The Maintainability rate is 4.58, interpreted as “Highly Acceptable”. Lastly, functionality rates are 4.43, interpreted as “Very Acceptable”. The application has been acknowledged as an essential tool for teaching mathematics, markedly as potential helping the student succeeding in academic performance. As a result, learning in mathematics became more enjoyable and fulfilling for both mathematics instructors and students.

Keywords: Alpha Testing, Augmented Reality, Beta Testing, Flashcards, Image Recognition Algorithm, ISO 25010, Mathematics, Mobile Application

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1.0 Introduction

Mathematics is the primary level that lays the foundation for mathematics contexts and life skills essential in the twenty-first (21st) century. Contrary to the common assumption that mathematics is complex, young learners enjoy and appreciate mathematics. Young learners naturally find wonders in patterns, solving puzzles, sketching a landscape or an object, watching sports or a game, and learning about money management. Harnessing the innate love for mathematical procedures to develop a cheerful disposition towards mathematics is essential.

Similarly, Chi (2023) stated that DepEd had implemented a National Learning Recovery Program. The project aims to solve the issue behind the low academic results of young Filipino students in both national and international tests. One of the components of the more extensive National Recovery Program run by DepEd is the National Mathematics Program. It attempts to support pupils in improving their comprehension of the principles of mathematics at every grade level. Nearly every element of a person's life is impacted by technology, which changes how people connect, communicate, and learn. An example of modern technology is augmented Reality or AR. “Augmented reality is a modern-generation technology that covers digital images and information in the real world around us”, was mentioned by Hayes (2024).

Likewise, Augmented Reality, or AR, is an improved representation of the environment created using computer-generated digital data. Today, Augmented Reality (AR) is prevalent on numerous websites, applications, and social media platforms, including Facebook's "My Day" and Instagram's "IG Story." One technology that can aid in enhancing educational learning results is Augmented Reality (AR). Augmented Reality in mathematics has the potential to significantly enhance the learning process by enabling students to learn through hands-on exploration, and it can also enhance traditional classroom teaching for children by modifying math lessons.

Augmented Reality offers numerous advantages when applied in the realm of education. In simple mathematical equations such as addition, using Augmented Reality in flashcards that served as image targets, it is possible to create a dynamic approach in which a learner can add the two numbers of flashcard by putting operational sign flashcard in between, and dynamically when the two numbers swapped in position between operational sign, the result is still correct.

1.1 Project Context

Augmented Reality is a modern-day technology that unites the real world with augmented objects, enhancing the user’s experience by overlaying virtual elements onto the physical environment. The Math-Wonders AR application system is an android

application designed to assist young minds in learning basic mathematical equations, becoming familiar with numbers and time, recognizing some basic shapes, and developing their problem-solving abilities. The Image Target type in Target Manager will be used as an element for the AR app to identify and monitor tangible items or markers in the actual setting. The researchers will design and create flashcards that act as targeted images; the object content will be displayed when the flashcards are viewed through the camera device. The system created by the researchers will feature some of the essential contents in mathematics, including Numbers, Geometry or Shapes, Addition, Subtraction, Multiplication, Division, basic understanding of money, and learning to read time.

The researchers, intended this study for grade 2 students who see mathematics as hard to learn. The mathematics teacher observed that some grade 2 students find complex learning, such as basic operations, counting, and comparing two numbers. The researchers recognize the potential of integrating Augmented Reality technology into Mathematics applications to help grade 2 students enhance their understanding of the subject. Instead of practicing the mathematics in traditional setup such as learning in blackboard, textbooks, and slideshows from tv screens, the grade 2 students will have other ways to learn and improve their mathematical skills. The Math AR app will help the Mathematics Instructors as well to improve techniques in teaching mathematics.

The mathematics contents that will be included in the system application are the following: Counting numbers, understanding odd and even numbers, greater than, less than, and equal signs, and learning to read time. Geometry, familiarize the basic shapes, and the user can rotate the geometry shapes and change the color. In the core operations, Addition, Subtraction, Multiplication, and Division will be incorporated into the application. A basic understanding of money will be understanding the coins and bills and applying essential addition and subtraction in money.

1.2 Statement of the Problem

This study entitled “Math-Wonders: Augmented Reality Flashcards using Image Recognition Algorithm for Enhanced Children’s Learning” was motivated by the desire to address issues with children’s mathematical education and improve learning experiences in mathematics by utilizing Augmented Reality (AR) and Image Recognition Algorithm.

1.2.1 Research Questions

1. Do the grade 2 students of the target school face challenges or difficulties in learning mathematics?
2. How can augmented reality help grade 2 students who have trouble learning mathematics overcome their mathematical difficulties?
3. Can Image Recognition Algorithm can be integrated in learning mathematics?
4. What are the results of the respondent's evaluation of the system?

1.3 Objectives of the Study

As the researchers transition from outlining the overarching objectives of this study, researchers will now delineate both the general and specific goals in detail, providing a comprehensive roadmap for the research.

1.3.1 General Objective

The study "Math-Wonders: Augmented Reality Flashcards using Image Recognition Algorithm for Enhanced Children's Learning" aims to enable young minds to learn how to study fun and intriguingly. Providing insightful information on the application of Augmented Reality (AR) technology and assessing its effectiveness as a cutting-edge tool to support children experiencing mathematical difficulties in their mathematical learning journeys.

1.3.2 Specific Objectives

- To identify what is the difficulty of particular topics in Mathematics for Grade Two (2) Students;
- To design and develop AR Based on Grade Two (2) Mathematics Learning Material based on the curriculum of the target school;
- To implement an Image Recognition Algorithm; and
- To evaluate the proposed AR System objectively using ISO 25010.

1.4 Scope and Limitation of the Study

This part highlighted the Scope of the study, and the Limitation of the Study.

The researchers have chosen Tagalag Elementary School as the beneficiary of this study. The target respondents for the study are grade two

students, grade two mathematics teachers, the mathematics coordinator, and IT experts. The software tools used to create the system application include Canva Pro, Unity 3D, Vuforia Engine, Blender 3D, and Inkscape. The tools and equipment needed for the system application will include a laptop, mobile devices, and custom-made flashcards designed specifically for use with the application.

The application system is intended for thirty-two (32) grade 2 students in Tagalag Elementary School. The featured content of the system includes Counting Numbers, including Odd and Even Numbers; comparing numbers using Greater than, Less than, and Equal signs; Learning about Money through knowing about bills/coins and applying basic operational addition and subtraction; Understanding time and becoming familiar with reading a traditional clock by recognizing its components; Learn basic shapes; Learn basic mathematical operation such as Addition, Subtraction, Multiplication, and Division.

The basic operations in mathematics will include addition, subtraction, multiplication, and division. Basic addition and subtraction will cover single-digit to single-digit numbers, double-digit to single-digit numbers, and double-digit to double-digit numbers. Basic multiplication will focus on the multiplication table. The basic division will cover number ranges from zero to ten, with only whole-number answers accepted; answers with decimal points will not be included.

Furthermore, the camera can only recognize images that are saved in the image target database. Flashcards may be downloaded straight from the application, and the flashcard file that is downloaded contains printing instructions and quality standards.

The system's number range for math content is from zero (0) to ninety-nine (99). Any negative numbers or numbers exceeding ninety-nine (99) will not be included in the application's content. The AR app can only employ flashcards created by researchers; the application will not recognize flashcards that the researchers do not create. The custom-made flashcards will have two versions: one featuring number from zero (0) to nine (9) and another featuring numbers in multiples of ten, from ten (10) to ninety (90). They will also include operational symbols for addition, subtraction, multiplication, division, and ten basic geometric shapes.

The AR application will be available exclusively on Android phones. The application is not downloadable from Google Play Store nor from App Store. The researchers will provide the application thru google drive link exclusively for the target school. The application will not be supported on web platforms, PC/Mac, consoles, or iOS devices. The specifications for the Android phones used in beta testing and demonstrations are as follows: The Android version must be Android 11, up to the latest Android 14 update; The processor should be at least a MediaTek Dimensity 6080 or higher from any related specification; The camera should have a minimum of 50-megapixel lenses; The display resolution is 1080x1920 up to 1080x2460 in width by height; Random Access Memory (RAM) should be at least 16 gigabytes, including RAM extension features available on Android devices; Read-only memory (ROM) must have at least 2 gigabytes of free storage; The application can run without the need for Wireless Fidelity (Wi-Fi).

The content for the application system will not involve some of the math content that is not part of the Grade 2 curriculum (e.g., Calculus, Pythagorean Theorem, Fractions, Introducing decimal numbers, Algebraic Expression…). All the content will be used for the application system, which will only focus on the curriculum of Grade 2 Mathematics.

Using other flashcards or photos will not be supported since the camera can only detect images that are part of the image target database. Users may choose the flashcards they need, download them, and print them on the paper or other materials of their choice. The user's selection of printing parameters and supplies will determine the final quality of the flashcards.

1.5 Purpose and Description

This study provides tremendous value to the following:

To the Children. Augmented reality therapy can significantly benefit children aged 6 to 8 years old facing math difficulties by enhancing their self-assurance, reducing stress, and enhancing their math abilities. Augmented reality could enhance comprehension and involvement in math by providing people with immersive and interactive educational opportunities.

To the Parents. Parents can anticipate a revolutionary impact on their children's attitude to mathematics learning by building an innovative solution that leverages

augmented reality (AR) technology. AR flashcards make arithmetic more entertaining and intriguing for young minds, providing parents with a practical and up-to-date resource to interact with their children's education actively.

To the Educators. The research could be very beneficial for teachers working with students who are having difficulties with math. Teachers will observe significant enhancements in their students' math skills and experience deep satisfaction as they witness their students engage in learning, self-growth, and overcoming mathematical obstacles.

To the Future Researcher. Future researchers can go into the details of how AR technology can be fine-tuned to meet the specific needs of kids with mathematics challenges, examining future adjustments and advancements. Furthermore, studying the long-term consequences of incorporating AR flashcards into educational curricula can provide important insights into the sustainability and effectiveness of such treatments.

2.0 Review of Related Literature and Studies

The chapter 2 covers the Technical Background, addressing how the application creation, Local and Foreign Review of Related Literature and Studies.

2.1 Technical Background

The chapter covered the necessary tools for creating an Augmented Reality app. A cell phone is a compact, light electronic device for sending texts, making calls, exploring the web, and accessing different applications. Thesis projects primarily use mobile phones as the main platform for implementing and engaging with augmented reality applications. The AR experience is improved using mobile phone characteristics such as the camera, processing power, and sensors, allowing real-time interaction with virtual things superimposed on the real world.

Flashcards are made by designing them using the Canva Pro version, printing them out on matte sticker paper, and adhering to a vellum board, which is put together using cutter paper. Three categories comprise the flashcards: Shapes (e.g., circle, rectangle, square, triangle, trapezoid, pentagon, hexagon, oval, octagon, and rhombus), Numbers (e.g., 0 to 9 and by 10 up to 90), and Operational Signs (e.g., plus, minus, multiply, and divide). Every flashcard design is created with care to guarantee visual clarity and learning efficacy.

Blender 3D, a free and open-source tool, was used to create the 3D models for the system application. 3D objects like numbers, operational signs, shapes, and figures are created in Blender 3D. Unity Hub will be used to create an augmented reality application. Setting up the scene, implementing AR functionality, and introducing interactivity are all part of Unity 3D. After extensive testing and performance optimization, the software is published to the target platform. Iterative improvements driven by user input inform future development. Vuforia Engine will be used to apply augmented reality. Vuforia Engine is an Augmented Reality development platform that provides tools and APIs for executing Augmented Reality technology in software and applications. Vuforia Engine is executed to easily incorporate augmented reality features like image recognition, object tracking, and spatial mapping, and it will be applied to Unity or Android studio projects.

2.2 Review of Related Literature

This chapter discusses the gathered information, important facts, and review materials that are relatively significant to the proposed topic. These related literature and studies were used as references for the completion of this project

2.2.1 Review of Related Local Literature

As stated by Guinocor et al. (2020), education is critical to the development of human capital and society, both of which are necessary for advancement in many facets of a nation. Activities that improve cognitive capacities, abilities, and attitudes are included in education; these activities lay the groundwork for individual and community progress. It fosters the essentials required to solve contemporary difficulties in a variety of professions, it is ingrained in curriculum around the globe. Mathematics defines the major contributions in modern life as it provides the foundation for advances in improving the world. Mathematics considered as universal language that transcends linguistic and cultural barriers to promote worldwide cooperation, communication, and innovation.

Likewise, Bernardo et al. (2022) stated that 50% of Filipino grade school pupils scored below the lowest competency level in mathematics, concerning the underscoring serious problems with the nation's educational system. These findings point to a pervasive lack of mathematical proficiency required for handling challenging problems, which is made worse by differences in instruction between public and private institutions. Students attending private schools typically fared better, highlighting disparities in access to resources and assistance for education. Public schools struggle with issues like limited financing, packed classrooms, and a lack of skilled teachers. These problems are made worse by socioeconomic circumstances that restrict lower-class families' access to higher education.

Moreover, Cabuquin et al. (2023) highlighted the critical role that mathematical proficiency plays in predicting high school achievement and the substantial correlation that exists between students' performance in mathematics and their overall academic success. The study reveals a

noteworthy affirmative correlation between mathematical proficiency with accomplishments in diverse academic domains, whereas subpar arithmetic performance is linked to inferior academic results. Crucially, the study finds no discernible gender disparities in math proficiency, indicating that both male and female pupils can succeed with the right assistance. Therefore, it is advised that secondary schools concentrate on giving every student a solid math education through individualized instruction and interesting activities.

Similarly, Pentang et al. (2021), focused on assessing the problem-solving abilities of the subjects, with an emphasis on number sense, measurement, geometry, algebra, and probability. The study found significant correlations between the participants' problem-solving abilities and factors such as sexual orientation, social status, parents' educational attainment, high school graduation, and preferred subjects. The study, which used a mixed-methods approach, found that participants who opted to teach mathematics outperformed those who picked other subjects in problem-solving tests.

As discussed by De La Rosa (2021), he provided evidence of how Augmented Reality (AR) can improve instruction so that a student with special needs can comprehend a lesson. This is accomplished by giving them the option to complete their courses utilizing real-world virtual representations that include sound, touch, and sight. Augmented Reality (AR) technology can be applied to create a multimodal educational experience that connects technology and education to be more effective and improve learning for the student. Teachers benefit from the usage of Augmented Reality (AR) because it allows them to use technology to tailor their teachings to the unique needs of their students.

2.2.2 Review of Related Foreign Literature

In the view of Pahmi et al. (2023) in mathematics education, augmented reality (AR) has become a game-changing tool that provides a novel approach to help students at all educational levels comprehend difficult ideas more thoroughly. From elementary school to university

education, AR expands in immersive and dynamic learning environment that covers a variety of mathematical topics like algebra, geometry, and statistics. Teachers may create a more dynamic and encouraging learning environment by integrating augmented reality (AR) into their lessons. This will boost students' mathematics confidence and skills, which will ultimately improve their academic performance and cognitive development.

As mentioned by Hidajat et al. (2023), Augmented Reality (AR) used in education are numerous, there is still a significant lack of research on how AR encourages mathematical innovation. This disparity emphasizes the necessity for in-depth research on the precise ways in which AR can foster creative thinking in mathematics. Research indicates that augmented reality (AR) has the potential to greatly improve students' mathematical cognitive capacities, problem-solving ability, selfconfidence, and social interaction. For the purpose of creating augmented reality applications that promote mathematical creativity, tools such as Unity3D and Vuforia are crucial. In addition to improving individual abilities, augmented reality (AR) can foster collaborative learning environments and enhance educational fairness, teaching quality, and curriculum alignment. Sustained transdisciplinary investigation is essential to realizing augmented reality's full potential and promoting creative methods in math instruction.

As highlighted by Yu (2023), stated that pandemic caused a significant shift in the education sector since augmented reality (AR) technologies became essential for enabling students to learn remotely from home. Through the use of Stata/MP 14.0, a thorough meta-analysis demonstrated that augmented reality (AR) greatly improved student attitudes and academic performance while encouraging creative teaching strategies. The investigation did, however, also reveal a discernible motivational difference between traditional educational models and ARassisted models, highlighting the intricate relationship between technology and student motivation. This result emphasizes the need for

more investigation into the successful integration of augmented reality (AR) into education to increase student engagement and success.

As described by Jaafar et al. (2022), demonstrated how important digital technology is to improving students' comprehension and visualization of academic subjects, especially mathematics. Digital tool integration is essential for boosting learning experiences in an era of rapid technological innovation because it provides new interactive ways for students to interact with the curriculum. The study, which concentrated on one university, demonstrates how digital technology can successfully handle the difficulties associated with teaching mathematics—a topic that is sometimes perceived as abstract and challenging. Students can engage in dynamic and captivating interactions with mathematical concepts through the use of educational games and applications, which can help make abstract topics more relatable and fascinating.

In the view of Ckho et al. (2021), apps that use Augmented Reality (AR) had shown to be extremely helpful for math-challenged pupils by making learning more dynamic and interesting. These apps design engaging classes that encourage active participation from students and improve their comprehension and memorization of mathematical ideas. By providing immersive experiences that enhance pronunciation, fluency, and general language proficiency, augmented reality (AR) also helps kids who are having language issues. Because it provides individualized solutions that cater to each learner's needs, this technology has proven very beneficial for students with certain learning difficulties. AR apps are a flexible tool that supports both academic learning and broader developmental goals, as they also aid in the development of motor skills and physical coordination.

2.3 Review of Related Studies

As the researchers embark on this comprehensive exploration of related studies, the researchers will begin by examining the broader research landscape before turning the focus to the distinct insights offered by both local and foreign studies, providing a well-rounded perspective on the subject matter.

2.3.1 Review of Related Local Studies

Based on Lapinid et al. (2022), a comprehensive strategy that considered socioeconomic circumstances, non-cognitive, and metacognitive aspects is needed to address the numerical difficulties that Filipino kids encounter. Students without internet-connected mobile phones face increased educational disparities due to limited access to important learning resources. Due to their parents' low-income jobs, students from lower socioeconomic backgrounds may lack tutoring and academic support opportunities. Students who lack motivation and do not intend to pursue further education may also show a lack of overall interest in school. Poor critical thinking abilities can also hinder struggling pupils' comprehension of mathematics. Teachers and legislators can create focused interventions to give all Filipino students an equitable, superior mathematics education by tackling these interconnected concerns.

As stated by Moneva et al. (2020), self-confidence is a strong belief in one's abilities and potential for success that is created through positive feedback and support from peers, mentors, and friends. It is frequently considered the cornerstone of personal empowerment. Self-confidence, which is based on self-worth, increases when people face difficulties head-on and with resiliency and resolve. It is a dynamic attribute that may be developed with deliberate effort and outside support, as opposed to an innate trait. By providing personal mentoring and assistance, especially when it comes to solving mathematical challenges, teachers play a critical role in helping students develop this sense of self-confidence.

Elivera et al. (2020) mentioned that the rapid progression of technology offers unprecedented opportunities for educational institutions worldwide to transform teaching and learning processes. Augmented Reality (AR) is emerging as a vital component in this shift. By introducing immersive experiences to deepen comprehension and application of theoretical concepts, AR boosts classroom participation and fosters interactive learning. The study underscores the need for learner-centered approaches that prioritize engagement and experiential learning,

recognizing the limitations of traditional lecture-based methods. The project seeks to tackle this by developing an innovative AR mobile application that leverages marker-based technologies, such as Blippar, to integrate virtual content into real educational contexts.

As reported by Buasen et al. (2020), students' interest and curiosity in mathematics significantly increased due to interactive manipulatives, with many expressing a stronger inclination to pursue mathematics degrees after using these tools. Pupils felt that these manipulatives enhanced their understanding and performance in mathematical concepts. Interestingly, both students intending to major in non-math fields and those aiming for mathematics majors showed similar levels of interest and curiosity toward the interactive tools. Both groups agreed that these manipulatives influenced their motivation to explore math-related subjects further. Overall, interactive manipulatives were found to enhance comprehension and make mathematics more engaging, enriching the students' learning experience.

As indicated by Cabauatan et al. (2020), an increasing number of students are leveraging new technologies, such as software and applications, to alleviate their workload and enhance the organization of their coursework. These tools offer flexible solutions that can automate certain tasks, expedite information access, and simplify educational processes—ultimately saving time and allowing students to focus on more in-depth study. Despite the numerous benefits of modern technology, some students continue to prefer traditional methods, such as textbooks and face-to-face instruction.

2.3.2 Review of Related Foreign Studies

As noted by Khasawneh et al. (2021), mathematics anxiety represented a significant issue that spans various disciplines across multiple countries and sectors. The emergence of anxiety related to mathematics may be influenced by gender, with females demonstrating a greater vulnerability to mathematics anxiety than their male counterparts. Factors such as mathematical confidence, values, and self-efficacy are closely linked to self-awareness. This anxiety is characterized by a state of

tension and unease that hinders an individual's ability to carry out mathematical tasks, manipulate numbers, and solve problems in a wide range of everyday and academic situations. Improving these factors could ultimately help alleviate mathematics anxiety and enhance overall performance.

Garzón et al. (2020) suggested that numerous studies examining the benefits and challenges of augmented reality (AR) have shown its potential to enhance instruction and learning. This is why AR is becoming increasingly prevalent in education. Despite the promising advancements, a significant knowledge gap remains regarding the instructional strategies needed to effectively integrate AR. The technological capabilities of augmented reality in education are not as crucial as the pedagogical approaches utilized in its application. It is essential to explore the interactions between learner-centered pedagogical frameworks and AR enhanced teaching methods to fully harness AR's transformative potential.

As highlighted by Kljun et al. (2020), despite increasing interest and potential advantages in education, augmented reality (AR) remains an area that has not been fully developed. AR holds significant promise for enhancing education; however, mixed findings regarding its effectiveness have arisen from small sample sizes and short durations in studies. With technology becoming more accessible, AR applications are gaining popularity.

Russo et al. (2020) emphasized that reform-oriented teaching highlights the importance of students working through challenging mathematical problems to develop deep conceptual knowledge and skills. However, actual data shows that many teachers are reluctant to assign difficult tasks to their students. A study of 93 early-career elementary teachers in Australia revealed that while approximately 75% of teachers believed that difficulty is beneficial for learning—fostering resilience, problem-solving abilities, and peer interaction—a smaller group (16%) felt that challenges should be properly scaffolded and tailored to meet the needs of the students.

Yildiz et al. (2021) asserted that augmented reality (AR) is an advanced technological innovation that combines virtual elements with real-world environments to create interactive experiences that seamlessly blend digital and physical realms. While AR has applications in various fields, including entertainment and healthcare, its most significant impact is seen in education. By integrating digital content with physical objects, augmented reality has the potential to transform traditional teaching methods, promoting a more interactive and immersive learning environment.

2.4 Definition of Terms

To facilitate the understanding of this study. Different terms are defined herein.

Operational Terms

The key concepts of this study are operationally defined as follows:

Cognitive Thinking. In the context of this study, cognitive thinking refers to the mental processes involved in acquiring, processing, and applying knowledge, including aspects such as problem-solving, reasoning, and memory.

Digital Technology. In the context of this study, it focuses on improving the students' comprehension, visualization, and knowledge acquisition of the lessons.

Education. In the context of this study, it is essential to the development of society and is crucial in creating the human capital required for advancement across all national domains.

Flashcards. In the context of this study, flashcards are operationalized as small cards with information or questions on one side and corresponding answers or cues on the other, designed for efficient memorization and quick review.

Technical Terms

Specialized vocabulary unique to their respective fields is defined as follows:

AR Application. Augmented Reality (AR) application is a software program that utilizes AR technology to enhance the learning experience by superimposing virtual objects and information onto the real world. The AR application aims to create interactive and immersive learning experiences, allowing users to engage with educational content in a dynamic way that combines digital elements with their physical surroundings.

Blender 3D. Blender 3D is a free and open-source software tool used for creating 3D models. It allows users to design and develop three-dimensional objects, such as numbers, operational signs, shapes, and figures.

Flashcards. Flashcards are educational tools specifically designed to enhance learning through visual and tactile engagement. They consist of cards featuring different categories, including Shapes, Numbers, and Operational Signs. Each

flashcard is carefully designed for visual clarity and educational efficacy, making them effective aids for teaching fundamental concepts in mathematics and geometry.

Unity Hub. A software platform used for developing augmented reality applications. It serves as a central interface for managing Unity projects, allowing users to set up scenes, implement AR functionality, and introduce interactivity within applications. After thorough testing and performance optimization, the application can be published to the target platform.

Vuforia Engine. An Augmented Reality development platform that offers tools and APIs for implementing AR technology in software applications. It allows developers to easily incorporate AR features such as image recognition.

3.0 Design and Methodology

In preparatory to develop a system, the researchers visualized the design of the system they intend to build based on the data they have collected. In this part, the researchers demonstrate the design and methodology of their objectives.

3.1 Conceptual Framework

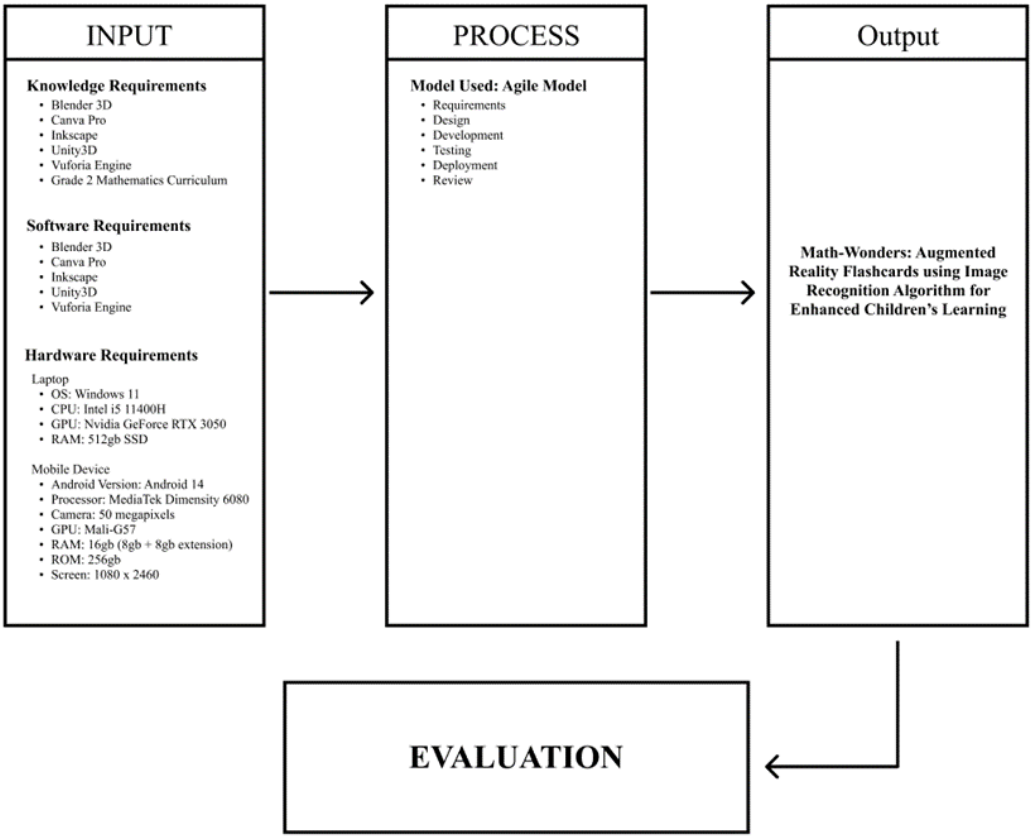

Figure 1: IPO Diagram of Math-Wonders App

In figure 1 it showed the Input, Process, and Output for creating an AR application. The knowledge required for the app created were Blender 3D, Canva Pro, Inkscape, Unity 3D, and Vuforia Engine, alongside the Grade 2 Mathematics curriculum.

The software requirements for building the system application were Blender 3D, a 3D creation software with a software version 3.6 or newer version. Canva, with a Pro version subscription, was a tool designed to make digital art and 2D content. Inkscape is a tool used to create buttons for the application. Unity Hub was a software tool for creating an AR application system and software version 3.8 or newer. Vuforia Engine, Vuforia Engine helped the application execute the Augmented Reality features.

The hardware used for the creation of the application was a laptop, Windows 11 operating system version, Intel i511400H for the processor, NVIDIA GeForce RTX 3050 4 GB in graphical user interface, 16 GB Random Access Memory storage, and at least 120 GB of free storage. The specification was proved to make the application smooth and less lagging. We used Android phone as hardware used for alpha testing and beta testing. An Android phone with version 14 or newer, Dimensity 6080 or higher specification of CPU, rear camera 50 megapixels, 16 GB Random Access Memory storage, with two GB free storage of Read-only Memory storage, and a screen size of 1080 by 2460 pixels.

The agile model was a dynamic approach to software development characterized by its iterative nature and adaptability. Rooted in agility, this methodology prioritized flexibility and responsiveness over rigid planning. In the Agile process model, projects were divided into smaller, manageable iterations, each with its own set of tasks and objectives. Unlike traditional methods, Agile did not rely heavily on long-term planning but instead focused on delivering value incrementally.

After executing the input and process diagram, it had the product of the output. The Math AR app ran its functions together with flashcards; the user had an interactive supplementary tool to help familiarized with the topics, take a test on their knowledge of what they can learned in the curriculum, and explore the Augmented Reality Technology.

Through evaluation, the researchers systematically collected information and insights from end-users and IT Experts, enabling the researcher to gather their feedback, opinions, and experiences regarding the system in question. This feedback allowed the researchers to gain valuable insights into the strengths, weaknesses, areas for improvement, and overall satisfaction levels associated with the system.

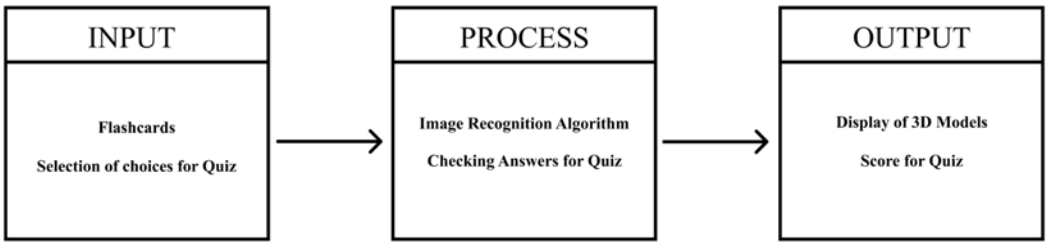

Figure 2: IPO Diagram of Math-Wonders AR App System

In figure 2 it pointed out the Input, Process, and Output Diagram of Augmented Reality and math quiz works in the AR app system. The input diagram showed on how

Augmented Reality work; flashcards will be used as image targets to trigger the Augmented Objects in the application. The Image Recognition Algorithm is used in the process diagram to make the Augmented Reality work for the application system.

Image recognition allows the application to identify the flashcard in the image, recognized patterns and regularities in the image data and later classify it into categories for interpreting image patterns. After the process is applied, the display of 3D models/objects on the user's device will be the expected outcome of the app.

The diagram addressed the process of math quiz works, the input diagram showed the selection of choices for the quiz where the user will saw the timer above the question and multiple choice that contains a single answer. When the user answers all ten questions randomly, the output outcome is that the app will show the user's score.

3.2 Software Design

The Software Design defined the following diagrams and descriptions on how the application develop, application works, and how the application interacts to the user.

3.2.1 System Architecture

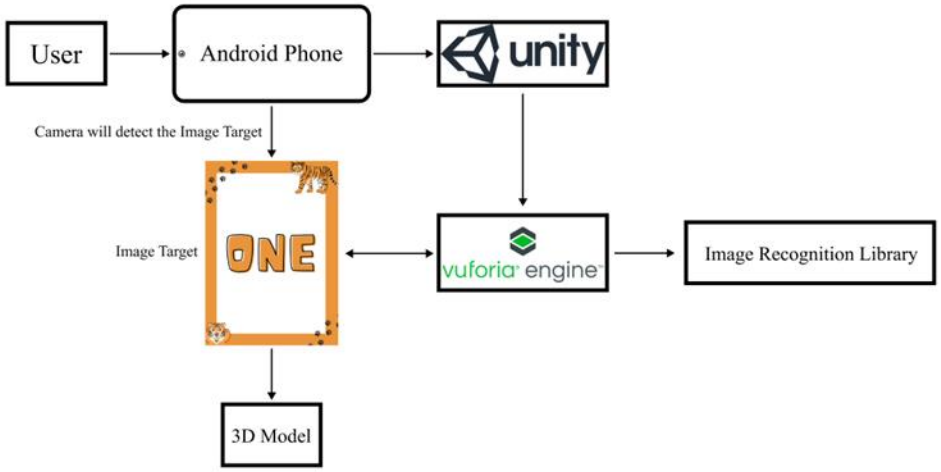

Figure 3: System Architecture in AR

In figure 3 it highlighted the system architecture of the Math-Wonders AR application. The figure emphasizes how Augmented Reality works for the app. The user interacted with the application made in Unity using an Android phone device. The user played the AR in the app, and using the physical flashcard, the user placed the flashcard on a surface (e.g., table, desk...) and face the camera device. The

flashcard image was stored in the Image Recognition Library, Vuforia Engine. The Vuforia engine is connected to the Unity application. The flashcard will serve as an image target for the app. When the device camera detected the image target, the application made in Unity confirmed to the Image Recognition Library, Vuforia. When the user showed the flashcard in the device camera, the image recognition library will validate the flashcard if it is recognized on the stored data. When the library recognizes the flashcard as a match from the stored data, the app will trigger the AR and display the 3D model/objects.

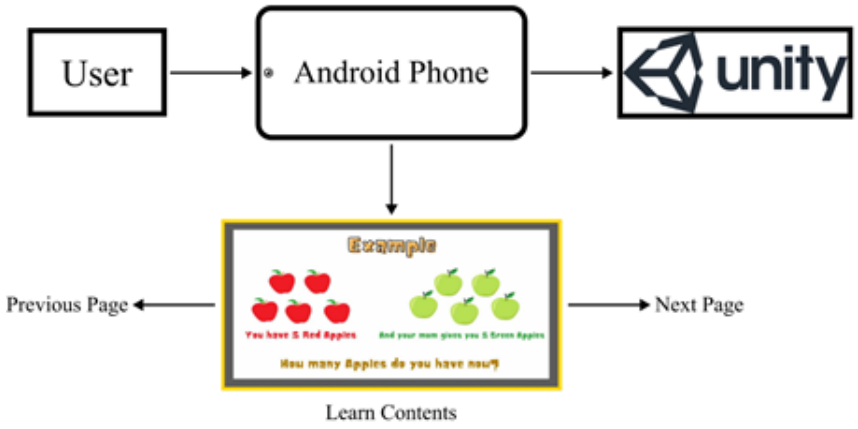

Figure 4: System Architecture in Learn Content

In figure 4 it focused on how the user interacts with the Learn content in the app. The learn content is one of the features included in the app. The learning content will be based on the math topics selected for the application. When the user interacts with the Learn content, the user can click next or previous to see the Learn content pages.

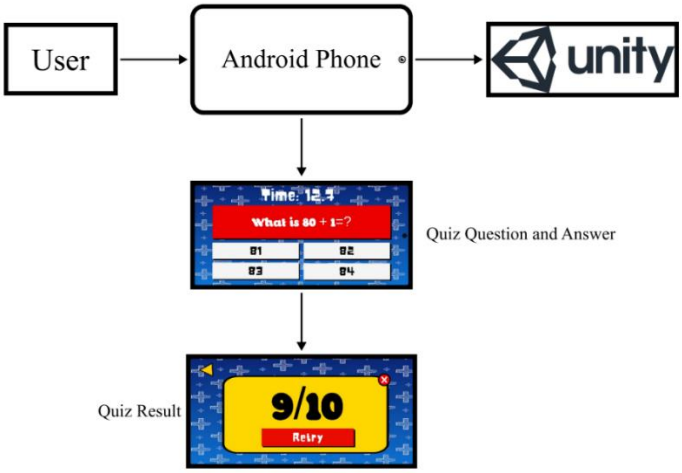

Figure 5: System Architecture in Quiz

In figure 5 it emphasized on how the user will interact with the Quiz system in the app. A user played the Quiz button triggered with the Timer, Question and Answer Choices on the action scene. In Quiz Timer, Question and Answer Scene, the user cannot pause or return until it is finished. The quiz contained ten randomly questions from 20 inserted into the app. Each question has had twenty seconds. The quiz result showed after the user answers all ten questions. The user can restart the quiz again or return to the content selection by pressing the close button.

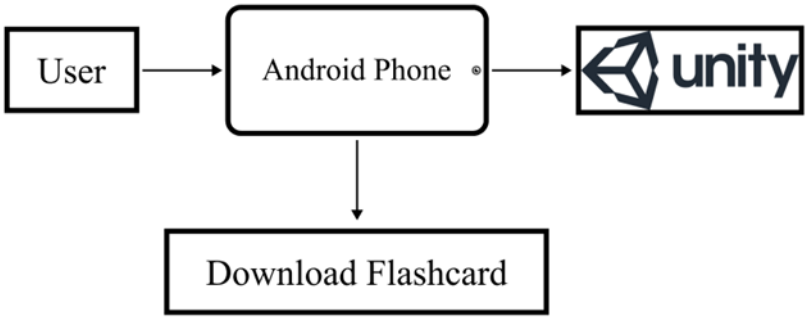

Figure 6: System Architecture in Download Flashcard

In figure 6 it showed the user could generate the flashcard through the app by downloading the pdf format. The pdf file contained of instructions on how to download and specified the flashcard size to run the AR in the app smoothly. The user will download the flashcard pdf file through the app and save it to the device. The user can connect to the printer and generate the flashcard. The alternative way

the user, if the device is not compatible with print, is to send the file to a PC / Laptop and start to print the flashcard file pdf.

3.2.2 Context Diagram

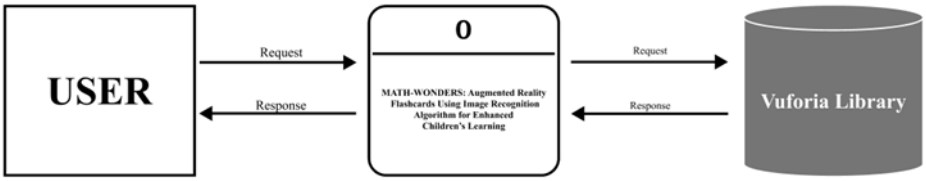

Figure 7: Context Diagram

In figure 7 it featured the overview of high-level operations in the Math-Wonders AR application. The user requested to play Augmented Reality on the app through the flashcards as an image target that will trigger the AR app. The user will display the flashcard to the device camera from the AR app, and the app will be sending request to Vuforia Library, validating the flashcard showed in the device camera. The Library will respond to the app if the flashcard has been validated and recognized. The application received the response from the Library, and the app will show the response to the user by displaying 3D objects to the app, proving that the Library recognized the flashcard shown in the device camera and recognized it as an image target stored in the Library.

3.2.3 Use Case Diagram

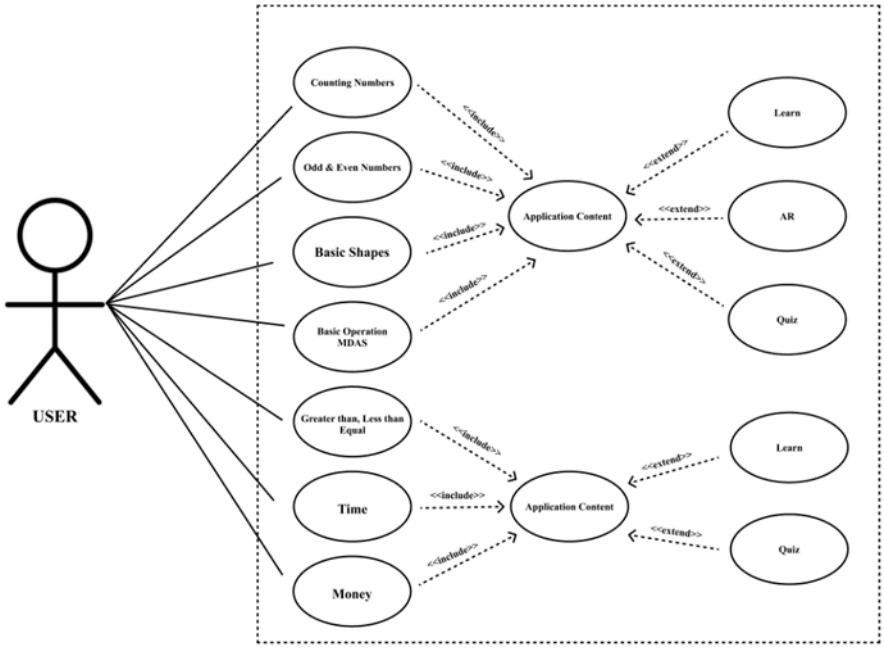

Figure 8: Use Case Diagram for Math Wonders

The use-case diagram for the Math-AR app addressed on how the user interacts with the app system as shown in figure 8. The user engaged with Math topics included in the app, such as counting numbers, Odd and even, basic shapes, basic operations (MDAS), greater than, less than, and equal, learning time, and basic understanding of money. Each of the topics are linked to three main features: Learn, where the users can review the topics; AR, which performs the AR features of the application; it requires the custom-made flashcard to operate the AR; and Quiz, where the users can take a small test from what they learn in the topic. The diagram showed how the functions are associated with the application's content, offering a supplementary tool that combines traditional learning, Augmented Technology, and taking tests.

3.2.4 Flowchart

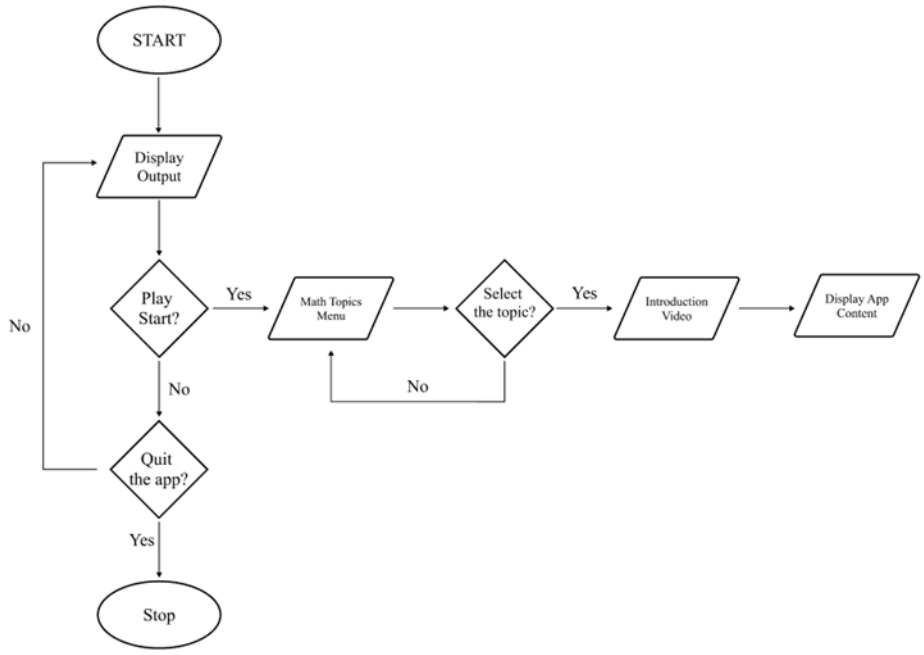

Figure 9: Program Flow Chart Diagram for Main Menu

In figure 9 it indicated the Program flow chart diagram for the Math-Wonders AR app. The user will start the app first, which will display the main menu output, and the user will see the play button and quit button. The application will stop if the user chooses to quit the button. The app will proceed to the Math Topics menu when the user plays the start button. When the user selects a math topic, the application will proceed to an introduction video, where the user will see a video from a math instructor introducing the math topic. The user can skip the video, and the application will display the app content: Learn AR and Quiz content.

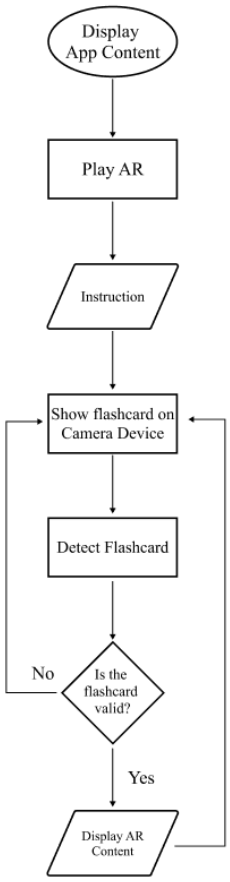

Figure 10: Flow Chart Diagram for AR

In figure 10 it demonstrated the Display app content for the AR. When the user played the AR button in the app, first it will display instructions on how to use the AR app. The user can close the instructions and proceed to the AR contents; the user will show the flashcard on the Camera Device. When the flashcard is detected from the camera device, the app will proceed to displaying AR content, confirming that the flashcard shown is valid and that part of the data is stored in the library. When the application finishes confirming and validating the flashcard shown in the camera device, the application will display the AR content. If the user wants to show another flashcard, the user will show another flashcard to the camera device and repeat the process.

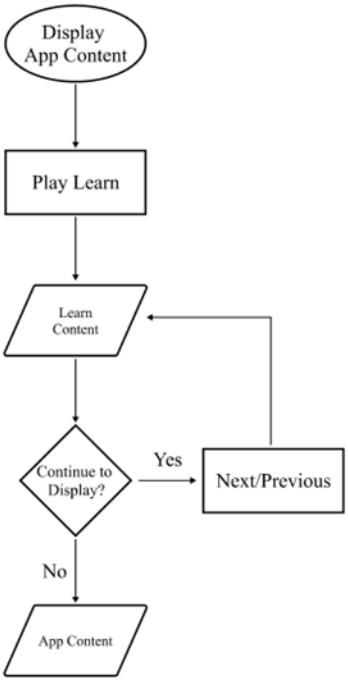

Figure 11: Flow Chart Diagram for Learn Content

In figure 11 it showed the program flow chart for the Math-Wonders AR app for learning content. It starts when the user plays the Learn button from 'Display App Content'. The user will encounter the Learn Content. The learning content contains multiple image slides about a specific math topic the user chooses. The user can go next and previous to the Learn content. When the user finished viewing the Learn content, the user can click the back button to go back to the App Content menu.

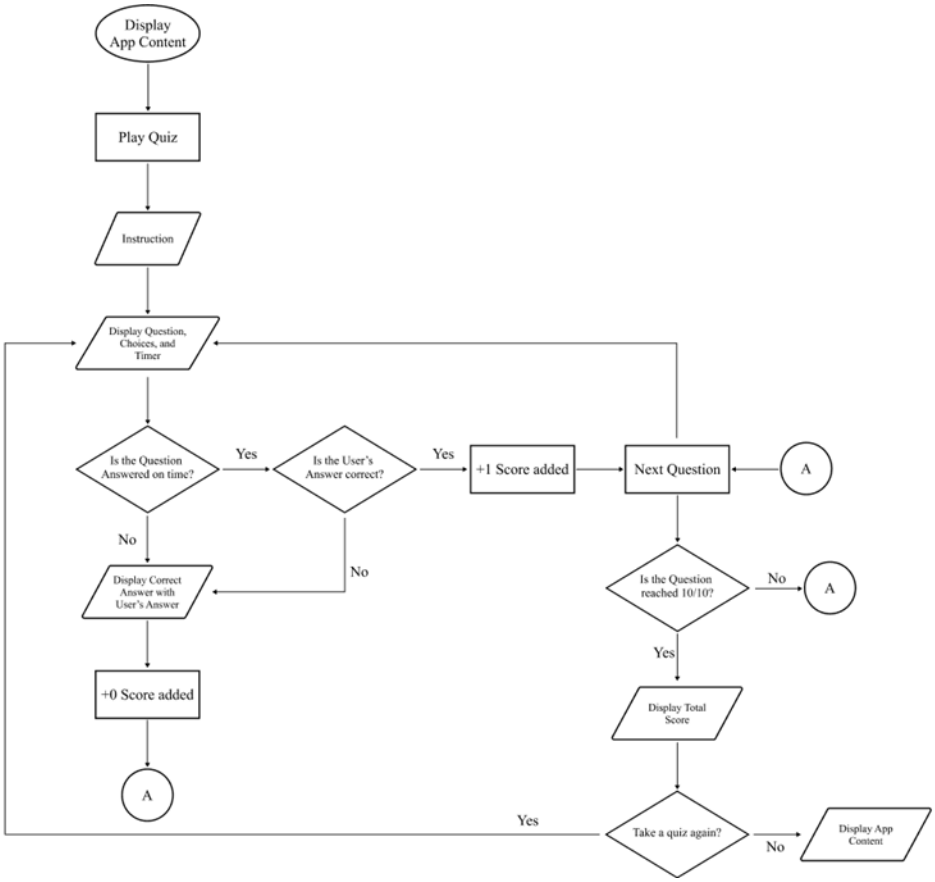

Figure 12: Flow Chart Diagram for Quiz Content

In figure 12 it showed the program flow chart of the Math-Wonders AR app for the Quiz feature. The user can play Quiz from App content. The quiz feature will start by showed the instructions on how the quiz works. After viewed the instructions, the user can start the quiz. The quiz will display the questions, answer choices, and timer. If the user does not answer the question on time, the user can see the correct answer together with the user's answer, and will count as a wrong answer for the question and will not gain points in the total score. When the user answers the question on time and the answer is correct, the user will gain one (1) point to the total score. If the user answered the question on time but does not get the right answer, the app will show the correct answer, count as the wrong answer, and not gained points in the total score. If the question reached ten (10) questions, it will show the total score of the user, and if the question still needs to reach ten (10) questions, it will proceed to the next question. The user can decide whether to retake the quiz or return to the app content menu if the quiz is finished.

3.2.5 Wireframe/Storyboard

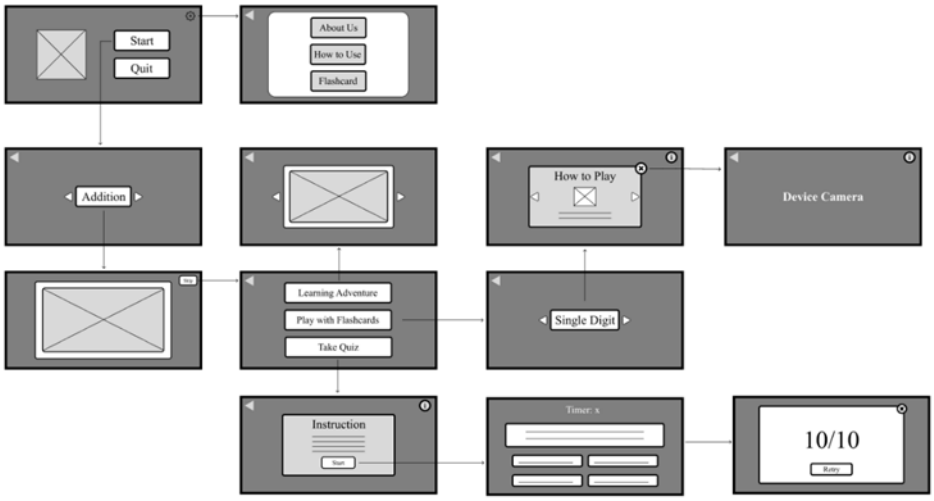

Figure 13: Wireframe / Storyboard of Math Wonders AR app

In figure 13 it illustrated the Wireframe/Storyboard of the Math Wonders AR app. The app will start in the Main menu, containing the start button, settings gear icon, and Quit button. When the user clicks the setting gear icon, the content will go to the 'About Us' button, 'How to Use' button, ‘Flashcard’ button where the user can generate flashcard through printing it, and 'Back' button to return to the menu. The quit button will close the app. The 'Start' button contains math topics (e.g., Counting Numbers, Basic Shapes, Addition,...). When the user clicks the Math content, the Scene will move to the introduction video where the topic is chosen, and the user can click the 'Skip' button. The user will go to the choosing of the content scene. This Scene will choose the content of the math topic that has been chosen.

As soon as the user chooses 'Play with AR,' the user will go to another scene where the user will choose the type of digits in the content to be executed. This Scene will only take effect with basic operations such as addition and subtraction. The user can choose from 'Single Digit to Single Digit Number,' 'Double Digit to Single Digit Number,' and 'Double Digit to Double Digit Number.' The Scene is not supported in choosing a certain digit number, which will proceed to the AR Scene, where the user will encounter instructions on operating the AR scene.

Once the user chooses the 'Learning Adventure' button, the user will go to the learning content topic, where the user can move the slide through the 'next' button and the 'previous button.' When the user chooses the 'Take Quiz' button, the Scene will go to the quiz and start. While taking the quiz, the user cannot pause it and must finish it. The quiz contains ten random questions from 20 questions stored in the app. When the quiz is done, the user can see the score, and the user can retry the quiz again.

3.3 Software Development

This phase is dedicated to showing the development of the software. This part will show the Agile Model, Software Development Life Cycle, and Image Recognition Algorithm

3.3.1 Agile Model

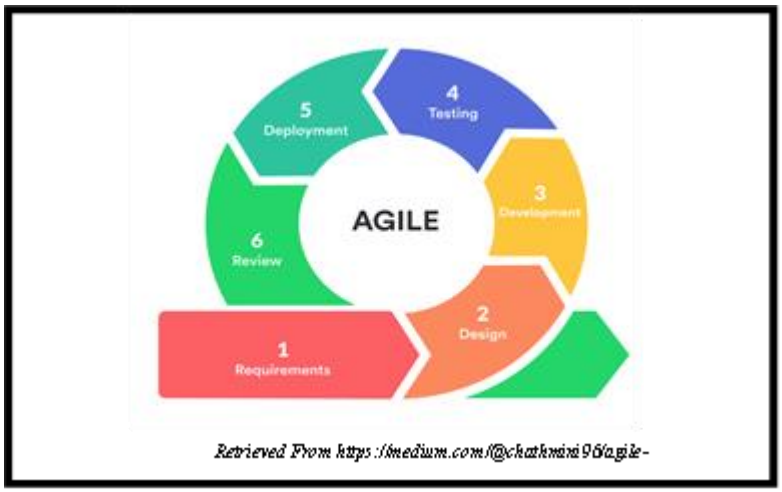

Figure 14: Agile Model

In figure 14 it emphasized that the Agile method is essential for the project, it is an iterative and incremental approach to building AR flashcards. The software development life cycle is divided into several phases in the Agile model, each of which plays an integral part in getting a project from conception to completion. In the research stage, the researchers collected data on the needs of grade 2 learners, identified software tools (e.g., Unity 3D, Blender 3D, Inkscape, Canva Pro) and hardware (e.g., laptops, Android phones) for developing the AR app, and obtained necessary permissions through consent and authorization letters. This phase also involved determining the math topics to include. In the design stage, the

researchers created 3D models, 2D designs, buttons, flashcards, and other visual elements prepared for integration into the Unity project.

In the development stage, all design elements were connected in Unity using C# programming, and AR functionality was enabled through Vuforia and flashcards. The testing phase involved beta testing with grade 2 learners, teachers, and experts to assess the app's performance and functionality, fixing bugs or issues. Once the app passed evaluation, it was deployed to the beneficiaries, including the primary education department and university alma mater. The review stage occurs 3-6 months post-deployment to gather user feedback for further improvements.

3.3.2 Software Development Life Cycle

Requirements. In the requirements phase, the researchers gathered the information for the beneficiary to determine the problem, to know the components used, such as software tools (e.g., Blender 3D, Unity 3D, Inkscape, Canva Pro,...), and hardware requirements (e.g., Laptop, Android Phone.) for developing Augmented Reality technology. The researchers will acquire the data they need for software tools, hardware requirements, and the math topic guides for grade 2 learners to proceed in the next phase. During this phase, the researcher will create consent letters, authorization letters, and other permits to allow the researchers to gather data.

Designing. In the designing phase, the researchers set up the unity project file in Unity 3D, conceptualized and create the 3D models using Blender 3D, Created the buttons for the app using Inkscape, Created the 2D instructions, Reminders, Backgrounds, flashcards, and logo using Canva Pro. When the researchers finished the designing task, they will proceed to the next phase, the Development stage.

Development. In the development phase, the researchers connected all the 3D model objects, 2D designs, and buttons to the project file in Unity 3D. For the programming language, C# would be used; the programming language would set up the functions and connect the design to create the app. To enable the augmented reality features, the flashcard images will be stored in Vuforia and input into the engine for the project file in Unity.

Testing. The researchers will used alpha and beta testing methods in the testing stage. Alpha testing is the way to determine whether the application meets its performance standards before it is released. IT Experts and math coordinator and teachers will handle alpha testing. After the alpha testing, beta testing will be conducted to grade 2 students from Tagalog Elementary School will be the ones to participate in beta testing. All the participants for testing will evaluate the application system based on its performance and functionality. The respondents will carry out a wide range of tests, such as user acceptability, system, integration, and unit tests; the objective is to find and fix any defects, bugs, or problems that may come up while the system is being developed so that is working correctly and satisfy the requirements.

Deployment. In the deployment phase, the researchers will deploy the system to the beneficiary once the alpha and beta testing are cleared. During the deployment, the application 'Math-Wonders AR App' and the custom-made Flashcard will be given to the beneficiary only for the system. After the deployment stage, the researchers will provide technical and application system assistance if there is a problem after the app's deployment.

Review. In the review stage, the researchers gathered feedback from the beneficiary on how the application after the deployment. The researchers will be open to the beneficiary about concerned about the system. The researchers' availability for concern will take only three to six months after the study is finished and passed system evaluation.

3.3.2 Image Recognition Algorithm

The Image Recognition Algorithm teaches machines to perceive visual data to human cognition, identifying objects or features within images or videos. By utilizing deep learning techniques and neural networks, these algorithms are trained on extensive datasets to comprehend patterns and characteristics within digital images, aiming to enable machines to interpret visual information similar to humans. Through this training process, Image Recognition algorithms aim to mimic human-like understanding by categorizing and identifying objects within images, advancing the capabilities of artificial intelligence in visual comprehension.

Image Targets served as recognizable images that Vuforia Engine can detect and track, facilitating various applications such as enhancing printed media and product packaging for marketing endeavors, gaming experiences, and visualizing products in their intended environments. These targets can encompass any planar image possessing ample detail for detection by Vuforia Engine, offering flexibility in application across diverse contexts and industries. Using Image Targets, Vuforia Engine enables seamless integration of augmented reality experiences into real-world scenarios, enriching user engagement and interaction.

The Math Wonders AR app employed image recognition algorithms to detect and analyze mathematical symbols and equations in physical flashcards, offering users an augmented reality platform for interacting with mathematical content. With deep learning and neural networks, the app effectively categorized and comprehended mathematical elements, assisting students in grasping intricate mathematical concepts visually. Furthermore, by incorporating image targets like flashcards, the app enhanced the learning journey by providing contextual relevance and overlaying interactive content directly onto recognized mathematical material, fostering an engaging educational experience.

3.4 Testing and Evaluation

This phase focused on evaluating how the augmented reality flashcards affected the math learning progress of children facing challenges in mathematics.

3.4.1 Respondents

This part will address the parts related to the respondents of the study. The respondents will specify the target respondents, location where the study will take place, what sampling used, addressed Data Management Plan, and Research Ethics.

3.4.1.1 Research Design

3.4.1.1.1 Quantitative Method

The quantitative method analyzed the numeric data gathered for the answer. This approach is often used to quantify the behavior, opinions, and attitudes to uncover patterns, test theories, or make predictions. Quantitative methods will be used

in the research to measure the effectiveness of augmented reality applications in improving mathematics performance and identifying common difficulties. The survey-questionnaire data will help to improve the content that will be placed in the system application.

3.4.1.1.2 Descriptive Quantitative Design

Descriptive quantitative research is collected and analyzed the numbers to describe the happenings among the respondents. The study will collect the data from respondents using survey questionnaires, which will be presented as numeric data. The data was examined using statistical methods to enhance the understanding and interpretation of the collected data

3.4.1.2 Research Locale

The study will take place in a certain school in Valenzuela City, Tagalag Elementary School where the goal is to support children experiencing mathematical difficulties. Because of its accessibility, the particular school in Valenzuela City is a capable research location. Researchers will form cooperation in this school to acquire participants. Researchers hope to build an open and supportive environment for children experiencing mathematical difficulties to engage with Augmented Reality Flashcards and experience a complete approach to mathematics learning.

3.4.1.3 Population and Sampling

The primary beneficiaries were thirty-two (32) expected grade two students who are currently enrolled for the school year 2024-2025, ages six to eight, enrolled at Tagalag Elementary School in Valenzuela City, requiring informed consent stated that the parents/guardian will allow their child to participate to the study. (2) Mathematics public teachers and (1) coordinator must be teaching grade two mathematics, with experience and willingness to participate. (5) IT experts with relevant expertise in software evaluation, Augmented Reality Technology, or

educational technology are eligible, requiring professional qualifications and willingness to provide technical insights.

For the Exclusion, the students who are studying at Tagalag Elementary School but not grade 2 are excluded. For Mathematics public teacher in Tagalag Elementary School the exclusion is the teacher who teaching in school, but not teacher mathematics or teaching in grade 2. For the IT Experts they must over five years of experience to check the system. These selected respondents will provide diverse perspectives and experiences for a comprehensive assessment of the Augmented Reality application.

The study used a purposive sampling technique for Grade 2 students in Tagalag Elementary School. The purposive sampling could help ensure that different segments of respondents are represented. Purposive sampling referred to intentionally selecting the participant based on the respondents need to the study.

3.4.1.4 Data Gathering Procedure

The researchers will give the study participant an authorized letter stating to conduct a study and an informed consent document. The consent letter includes research purpose, intervention type, participant criteria, voluntary involvement, study duration, risks, rewards, compensation, privacy, withdrawal rights, and principal investigator contact information.

The data gathering for this study includes obtaining survey data from the participants. The information gathering is confidential and restricted to internal university utilization. The questionnaire will be given to alpha and beta testers, such as the IT experts, math coordinators, math teachers, and users, to collect input on the operational features of the system application.

The researchers will obtain an authorization letter from the Division Office Valenzuela, granting permission for them to carry out the study at the designated school recipients, along with a consent form

explaining the purpose of the study and an assent form. The consent form, along with the assent form, will be given to each respondent individually.

The researchers will start by surveying participants to pinpoint problem areas, followed by creating and enhancing an intervention based on the findings. After completing the intervention, a final survey will be conducted to assess how effectively it enhanced participants' comprehension. Face-to-face data collection will be used to conduct beta testing and survey evaluation.

Identifying participants based on specific criteria and gaining their consent to participate in the study are part of the recruitment process. To establish the verified participants, they will complete a questionnaire evaluating the software's quality based on ISO 25010.

The study will last from February 2024 and will conclude in December 2024. The class will be interrupted for around 20 to 30 minutes when the researchers perform beta testing and survey evaluation.

3.4.1.5 Data Management Plan

The researchers will safeguard the data generated in the survey questionnaire. The individuals allowed to provide data access for this study include math teachers, the math coordinator, researchers, and the research advisor. In order to secure the data generated, the researcher will scan all the data findings to prevent loss from fire, flood, and other potential risks that could result in data loss. The data collected from the scanner will be saved in Google Drive, and only authorized individuals can access it. The data collected will retained only during the research study period. All the collected data will be deleted when the research study is complete.

3.4.1.6 Data Analysis

Data collected through the evaluation form will be analyzed using appropriate statistical methods. Likert scale answers will be statistically examined to identify patterns and trends in the data. Finding significant

insights that will improve the system's assessment and comprehension requires careful consideration during the data analysis.

3.4.1.7 Research Instrument

The first phase of the research is to conduct a survey questionnaire for grade two students to determine the specific problems students find in mathematics. With the data gathered, a statement of the problem was made. Before assessing the system application, a profiling survey is conducted to verify that the respondents meet the criteria.

The last phase is the evaluation form based on ISO 25010 to address this study's objectives and quantify the criteria aspects of the project's goal. The survey is intended to describe the system application; assessment will be conducted by participants who meet the specified criteria. To assess the perceived advantages of the project as an AR app and verify its potential as a supplementary tool for the intended respondents.

3.4.1.8 Research Ethics

The research study has undergone an ethical review by the OLFU-IERC (Our Lady of Fatima University Institutional Ethics Review Committee), a PHREB (Philippine Health Research Ethics Board) accredited Research Ethics Committee, in order to guarantee the proper use of respondents' responses for research purposes and to give a sense of security. The comprehensive evaluation process ensures that the research project conforms to recognized ethical norms and safeguards the rights and welfare of participants.

1. Voluntary Participation: Participation in this research is at your discretion and entirely voluntary. You hold the right to opt out of the study at any point, without any penalty or loss of benefits owed to you.
2. Right to Withdraw: Participants were made aware that there would be no pressure or coercion and that their participation in the study was entirely optional. They received guarantees that their choice to engage

or not would have no bearing on their standing with the organization or any related services or perks.

3. Informed Consent: The study utilized the WHO consent form, providing comprehensive information about the study's purpose, procedures, duration, and foreseeable risks and benefits. Before agreeing to participate, participants were given ample time to read, understand, and ask questions about the consent form.
4. Confidentiality: To protect the privacy of respondents, all data collected were kept strictly confidential. Identifiable information was anonymized or coded, and access to data was restricted to authorized personnel only. This ensured that personal details could not be traced to individual participants or their institutions.
5. Potential Risk: The study carefully outlined any possible risks to the participants, which were minimal and primarily related to the time and effort required for participation. Participants were informed of these risks and assured that measures were in place to mitigate them.
6. Benefits: The study highlighted the benefits of participation, including the potential to contribute to valuable research findings that could inform future practices and policies. Participants were also informed about any direct benefits they might receive, such as gaining insights into their own experiences or receiving summary results of the study
7. Support Communication: Clear contact information was provided so that participants could reach out with any questions, concerns, or complaints regarding the study. This included contact details of the research team, ensuring that participants could receive prompt and appropriate support if needed.

3.4.2 Testing Procedure

The proposed system “Math-Wonders: Augmented Reality Flashcards using Image Recognition Algorithm for Enhanced Children’s Learning” will use Alpha and beta testing procedures. It is an essential part of the quality assurance process, allowing developers to make necessary improvements based on real-world user experiences and feedback. Alpha testers are exclusive to IT Experts, Math coordinator, Math teachers, and Beta testing is only for end-users. Alpha and

Beta testing helps to improve the app through evaluation based on ISO 25010 or the Software Product Quality. The assessment would ensure the application passed the standard quality control.

The following step is the testing procedure of the Math-Wonders AR App:

Step 1: Installing first the application

Step 2: Click the start button to choose in the AR menu

Step 3: Launching the flashcards based on the chosen action in the AR menu

Step 4: Start to point the device to the flashcard

Step 6: Display the 3D model

3.4.3 Evaluation Procedure

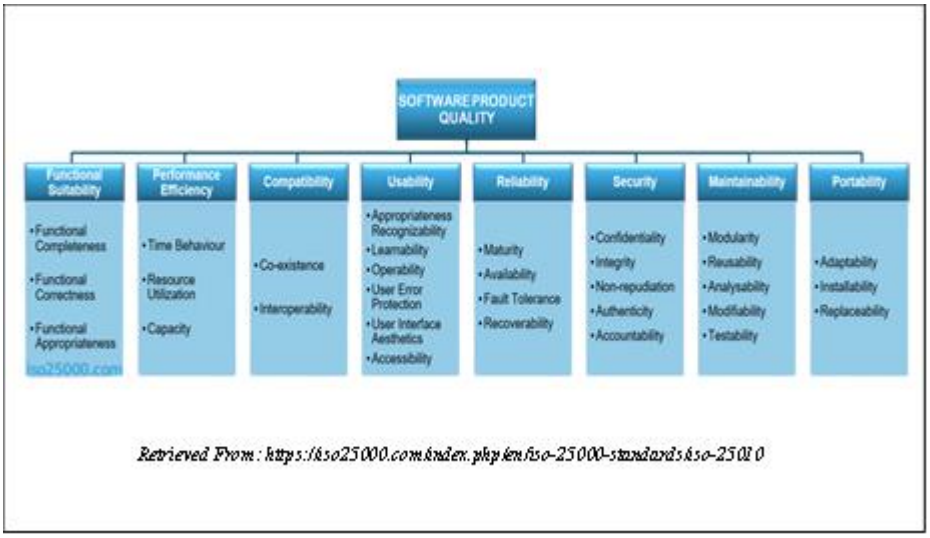

Figure 15: Software Product Quality (ISO 25010)

In figure 15 it showed Software Product Quality is a single model made up of eight qualities, which are further differentiated into sub-characteristics that contribute to the outcome of the relationship when a product is utilized in a certain environment. To evaluate the operation of the system, it will use the Likert Scale. The researchers used the ratings 1 to 5 with the different interpretations of each number. 5 – Highly Acceptable, 4 – Very Acceptable, 3 – Acceptable, 2 – Moderate Acceptable, and 1 – Unacceptable. Below are the characteristics of the system that need to be evaluated.

Functionality Suitability. The respondents will be going to evaluate the system based on three characteristics of functionality suitability. The three qualities are functional completeness, functional correctness, and functional appropriateness. For functional completeness, it will assess whether the application covers all specified tasks and meets user objectives. In terms of functional correctness, it will evaluate whether the application provides accurate results. Lastly, for functional appropriateness, it will determine if the application effectively accomplishes the specified tasks and objectives.

Performance Efficiency. Respondents will assess time behavior, resource utilization, and capacity in this characteristic. For time behavior, it will evaluate whether the system had acceptable response times, processing times, and throughput rates. In resource utilization, it will assess the efficiency of the resources used by the system while performing functions and meeting its requirements. Lastly, it will evaluate whether the system's maximum limits meet the required parameters for capacity

Usability. The respondents will evaluate the system based on appropriateness, recognizability, learnability, operability, and user-interface aesthetics. For appropriateness and recognizability, the respondents will assess whether the system is suitable for their needs. In learnability, it will evaluate whether the system could be used by the target respondents learning how to use the system. For operability, it will be assessed whether the system is easy to operate and control. In user interface aesthetics, it will be evaluated whether the interface provided a pleasing and satisfying interaction for the user

Reliability. The respondents evaluated the system based on maturity, availability, fault tolerance, and recoverability. In maturity, it will assess whether the system met the reliability needs under normal operation. In availability, the system’s operation and accessibility will be evaluated when required for use. In fault tolerance, it will be assessed whether the system will continue to operate in some conditions (e.g. is the app run without internet connectivity, etc...). In recoverability, it will be evaluated whether the system could recover after experiencing application faults or bugs.

Maintainability. The respondents will evaluate modularity and modifiability. In modularity, it will be assessed whether the application allowed changes to one component with minimal impact on other components. In modifiability, it will be evaluated whether the application could remain stable while undergoing modifications.

Portability. The respondents will be evaluated the adaptability and installation ability. In adaptability, the respondents evaluate if the application can be installed on other Android mobile phones and tablets. In install ability, the respondents evaluate if the application can easily be installed.

Table 1

Weighted Arithmetic Mean with Likert Scale

Numerical Value	Numerical Equivalent	Descriptive Rating
5	4.50 – 5.00	Highly Acceptable
4	3.50 – 4.49	Very Acceptable
3	2.50 – 3.49	Acceptable
2	1.50 – 2.49	Moderate Acceptable
1	1.00 – 1.49	Unacceptable

In table 1 it showed the Weighted Arithmetic Mean with Likert Scale will be used to investigate and explain the system with the formula above for finding the weighted mean and overall, by calculating it and when the results were already obtained, it can see now the result interpretation inside the table in descriptive rating column where in if the results were 4.50 – 5.00 with the interpretation of highly acceptable, 3.50 – 4.49 with the interpretation of very acceptable, 2.50 – 3.49 for every the interpretation of acceptable, 1.50 – 2.49 with the interpretation of moderate acceptable, 1.00 – 1.49 means the interpretation of unacceptable.

Formula for Weighted Arithmetic Mean:

$$Weighted\ Mean = \frac{\sum fx}{N}$$

fx = Number of Participants

$\sum$ = Summation

N = Total of Participants

4.0 Results and Discussion

This highlights the conclusions and findings that the researchers have compiled, thereby illuminating the tabular feedback to facilitate comprehension and evaluation of the data.

4.1 Project Description

The project system named Math-Wonders AR, is cutting edge software application gives user realistic 3D representations of numbers and fundamental shapes, bringing flashcards to life. Through the smooth integration of Augmented Reality (AR) technology into the educational process, user can improve their mathematical abilities by engaging with dynamic 3D objects, leading to a more profound comprehension of numerical ideas. Moreover, the incorporation of essential shapes in three-dimensional form facilitates geometry teaching by enabling-by-enabling users to visually investigate and become acquainted with basic geometric figures. This Android app not only advertises educational resources but also showed on how Augmented Reality can improve educational opportunities. Its capacity to recognize and display 3D Objects solely from flashcards allow users to have a concentrated and interesting learning experience.

4.2 Project Structure

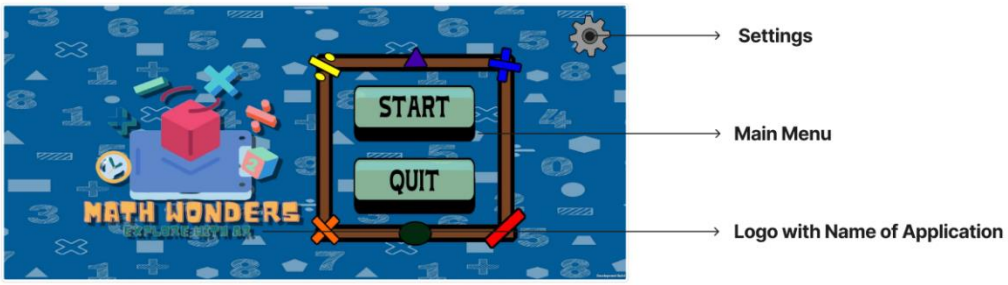

Figure 16: Main Menu of Math-AR app

In figure 16 it showed the Main Menu of Math-AR app. The menu contains the start button, settings gear, Quit button, and Logo of the App

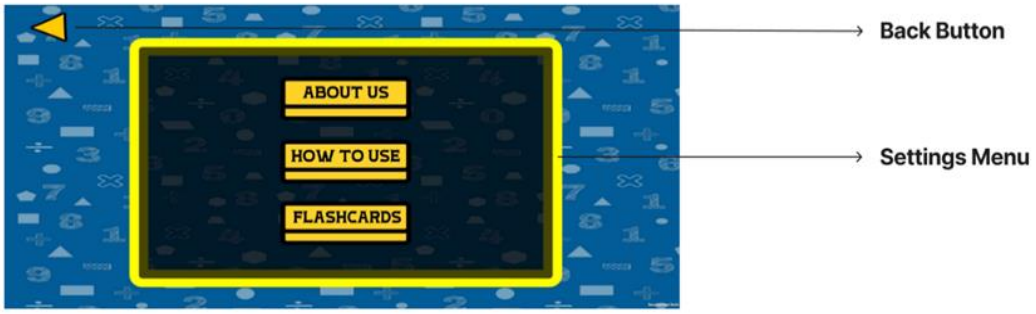

Figure 17: Settings of Math-AR app

In figure 17 it identified the content of the settings gear in Main Menu. The settings content has the About Us button which sees the group picture of the researchers and developers and the logos of the software/web used to create the application. How to Use button contained how to use the application.

Figure 18: Choose Topic Menu of Math-AR app

The math topics included in the application are number counts, identifying odds and evens, greater than, less than, equal, solving basic operational including add, minus, multiply, divide, familiarized basic shapes, money, and time.

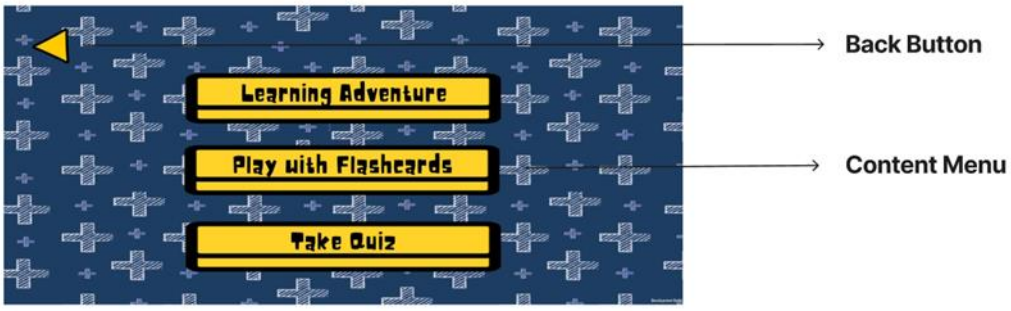

Figure 19: Choose Topic Content Menu of Math-AR app

In figure 19 it classified as the content topic for the Math-AR app. The content topic is Learn, AR, and Quiz. All the Math topic had content menu, for Money, Time, and Greater than/ Less than / Equal contained only Learn and Quiz content.

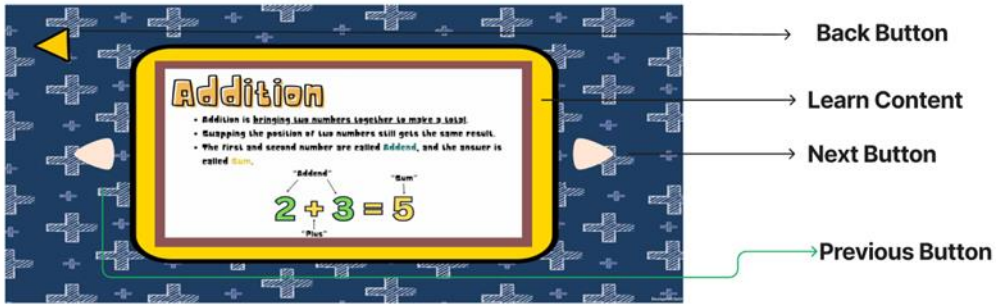

Figure 20: Learn Content of Math-AR app

In figure 20 it illustrated the Learn Content of Math-AR app. The user could next and previous the content slide.

Figure 21: AR Content Instructions of Math-AR app

In figure 21 it showed the AR content of Math-AR app. The AR content would show the instructions at the start. The user will display the flashcard in the device camera, allowed the app to validate and will show the 3D object models corresponded to the flashcard seed in the camera

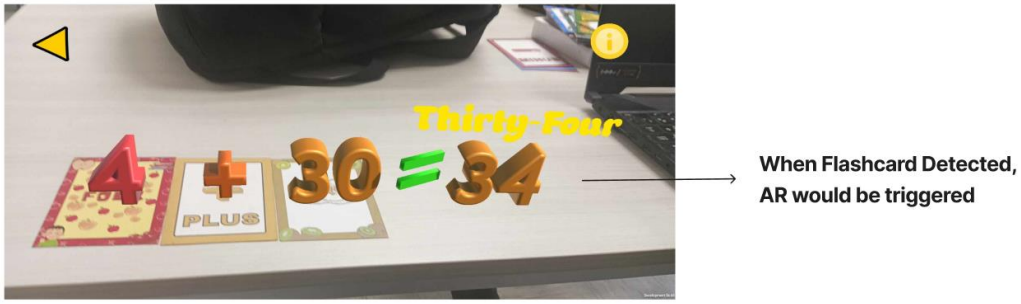

Figure 22: AR Content of Math-AR app

In figure 22 it demonstrated how AR works in the app. When the flashcard detected from the app through device camera, the AR will show and will be based on what flashcard detected on the camera.

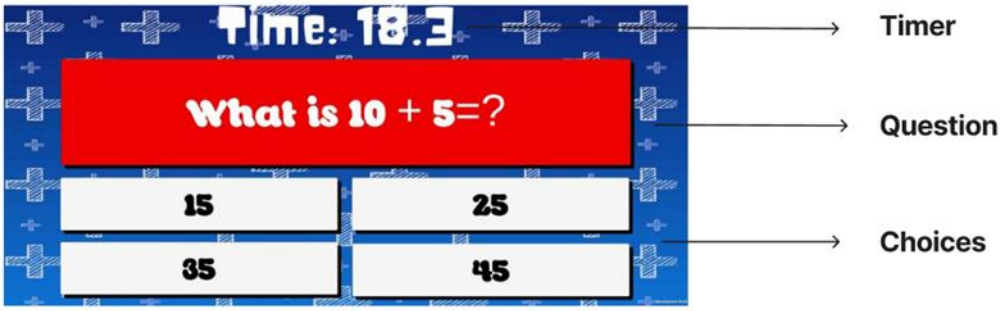

Figure 23: Quiz Content of Math-AR app

In figure 23 it demonstrated the interface of Quiz content in Math-AR app. The quiz had timer, question, and answer choices.

4.3 System Description

The system named Math-Wonders, combines AR technology with advanced image recognition algorithms to create a dynamic learning experience. By integrating playful, immersive learning experiences with educational content, MATH-WONDERS application aims to enhance children's understanding and retention of mathematical concepts, making learning both effective and entertaining. Application works with Android devices running the most recent API version up to 11 or higher as a minimum Android API level. For best results, the application needs at least 8GB of RAM and 500MB of storage. However, it is advised to use the app on a smartphone with a more recent version of Android, at least 16GB of RAM, and 1GB of free storage space for a flawless user experience. Users can guarantee seamless performance and complete functionality when participating in the augmented reality learning experience by fulfilling certain system requirements.

4.4 Implementation of Algorithm

This implementation of algorithm would explain the algorithm used to the application, codes used for AR and Quiz content.

4.4.1 Image Recognition Algorithm

```
void OnObserverStatusChanged(ObserverBehaviour behaviour, TargetStatus targetStatus)
{
    var name = mObserverBehaviour.TargetName;
    if (mObserverBehaviour is VuMarkBehaviour vuMarkBehaviour && vuMarkBehaviour.InstanceId != null)
    {
        name += " (" + vuMarkBehaviour.InstanceId + ")";
    }

    Debug.Log($"Target status: {name} {targetStatus.Status} -- {targetStatus.StatusInfo}");

    HandleTargetStatusChanged(mPreviousTargetStatus.Status, targetStatus.Status);
    HandleTargetStatusInfoChanged(targetStatus.StatusInfo);

    mPreviousTargetStatus = targetStatus;
}
```

Figure 24: Code for Image Recognition Algorithm

The Vuforia code's 'DefaultObserverEventHandler' class manages the tracking and identification of AR targets in order to perform image tracking. It monitors the targets' state, such as whether they are in view or not, using the 'ObserverBehaviour' component, and modifies the Unity environment as necessary. The 'OnTrackingFound' function is invoked when a target is discovered, allowing related components such as renderers or colliders to display items. On the other hand, the 'OnTrackingLost' method hides the objects and disables these components when the target is no longer monitored.

4.4.2 Augmented Reality

4.4.2.1 Counting Numbers and Odd and Even Numbers

```
if (appManager.isElementActive(element1.name) && appManager.isElementActive(element2v2.name))
{
    if (Vector3.Distance(element1.transform.position, element2v2.transform.position) < distance)
    {
        currentNumberCombination = DetermineNumberCombination12(element1, element2v2);
        if (currentNumberCombination != lastActivatedCombination)
        {
            ActivateBondObject12(currentNumberCombination);
            lastActivatedCombination = currentNumberCombination;
        }
        element1.SetActive(false);
        element2v2.SetActive(false);
        return;
    }
    DeactivateBondObject12();
    element1.SetActive(true);
    element2v2.SetActive(true);
    tiger.SetActive(true);
    foreach (GameObject m2 in monkey2)
    {
        m2.SetActive(true);
    }
}
if (appManager.isElementActive(element1v2.name) && appManager.isElementActive(element2.name))
{
    if (Vector3.Distance(element1v2.transform.position, element2.transform.position) < distance)
    {
        currentNumberCombination = DetermineNumberCombination12(element1v2, element2);
        if (currentNumberCombination != lastActivatedCombination)
        {
            ActivateBondObject12_1(currentNumberCombination);
            lastActivatedCombination = currentNumberCombination;
        }
        element1v2.SetActive(false);
        element2.SetActive(false);
        return;
    }
    DeactivateBondObject12();
    element1v2.SetActive(true);
    element2.SetActive(true);
    tiger2.SetActive(true);
    foreach (GameObject m in monkey)
    {
        m.SetActive(true);
    }
}
```

Figure 25: Code for Counting and Odd & Even Number

This code initiates certain activities based on the placements of particular game objects and determines whether they are active or not. It begins by determining if two components are active and whether their separation is smaller than a certain threshold. If this is the case, it uses 'DetermineNumberCombination12()' to find the combination of the two components, activates a bond object if the combination is new, and deactivates the two elements. It deactivates the link object and reactivates the components, as well as other objects like Tiger and every item in the 'monkey2 list', if the distance requirement isn't satisfied. The second section of the code follows the same logic, but it uses various elements, 'tiger2', the items in the monkey list, and different bond objects to activate and deactivate.

4.4.2.2 Addition, Subtraction, Multiplication, and Division

```
if (asdm.isElementActive(Element1.name) && asdm.isElementActive(Element2v2.name)&&
    asdm.isElementActive(Elementplus.name))
{
    float distToElementplus = Vector3.Distance(Elementplus.transform.position, (Element2v2.transform.position
    + Element1.transform.position) / 2);
    if (distToElementplus < distance)
    {
        currentNumberCombination = DetermineNumberCombination12(Element2v2, Element1);
        if (currentNumberCombination != lastActivatedCombination)
        {
            ActivateAnswer12_3(currentNumberCombination);
            lastActivatedCombination = currentNumberCombination;
        }
        return;
    }
}

if (asdm.isElementActive(Element1v2.name) && asdm.isElementActive(Element2.name)&&
    asdm.isElementActive(Elementplus.name))
{
    float distToElementplus = Vector3.Distance(Elementplus.transform.position, (Element2.transform.position
    + Element1v2.transform.position) / 2);
    if (distToElementplus < distance)
    {
        currentNumberCombination = DetermineNumberCombination12(Element2, Element1v2);
        if (currentNumberCombination != lastActivatedCombination)
        {
            ActivateAnswer12_3(currentNumberCombination);
            lastActivatedCombination = currentNumberCombination;
        }
        return;
    }
}
```

Figure 26: Code for Addition

```
if (msdm.isElementActive(Element1.name) && msdm.isElementActive(Element2v2.name)&&
    msdm.isElementActive(Elementtimes.name))
{
    float distToElementtimes = Vector3.Distance(Elementtimes.transform.position, (Element2v2.transform.position
    + Element1.transform.position) / 2);
    if (distToElementtimes < distance)
    {
        currentNumberCombination = DetermineNumberCombination12(Element2v2, Element1);
        if (currentNumberCombination != lastActivatedCombination)
        {
            ActivateAnswer12_3(currentNumberCombination);
            lastActivatedCombination = currentNumberCombination;
        }
        return;
    }
}

if (msdm.isElementActive(Element1v2.name) && msdm.isElementActive(Element2.name)&&
    msdm.isElementActive(Elementtimes.name))
{
    float distToElementtimes = Vector3.Distance(Elementtimes.transform.position, (Element2.transform.position
    + Element1v2.transform.position) / 2);
    if (distToElementtimes < distance)
    {
        currentNumberCombination = DetermineNumberCombination12(Element2, Element1v2);
        if (currentNumberCombination != lastActivatedCombination)
        {
            ActivateAnswer12_3(currentNumberCombination);
            lastActivatedCombination = currentNumberCombination;
        }
        return;
    }
}
```

Figure 27: Code for Multiplication

```
if (minusManager.isElementActive(Element1.name) && minusManager.isElementActive(Element2v2.name)&&
    minusManager.isElementActive(ElementMinus.name))
{
    float distToElementMinus = Vector3.Distance(ElementMinus.transform.position, (Element2v2.transform.position
    + Element1.transform.position) / 2);
    if (distToElementMinus < distance)
    {
        currentNumberCombination = DetermineNumberCombination12(Element2v2, Element1);
        if (currentNumberCombin                (field) string SSD.currentNumberCombination
        {
            ActivateAnswer12_3(currentNumberCombination);
            lastActivatedCombination = currentNumberCombination;
        }
        return;
    }
}

if (minusManager.isElementActive(Element1v2.name) && minusManager.isElementActive(Element2.name)&&
    minusManager.isElementActive(ElementMinus.name))
{
    float distToElementMinus = Vector3.Distance(ElementMinus.transform.position, (Element2.transform.position
    + Element1v2.transform.position) / 2);
    if (distToElementMinus < distance)
    {
        currentNumberCombination = DetermineNumberCombination12(Element2, Element1v2);
        if (currentNumberCombination != lastActivatedCombination)
        {
            ActivateAnswer12_3(currentNumberCombination);
            lastActivatedCombination = currentNumberCombination;
        }
        return;
    }
}
```

Figure 28: Code for Subtraction

```
if (dsdm.isElementActive(Element1.name) && dsdm.isElementActive(Element2v2.name)&&
    dsdm.isElementActive(ElementDivide.name))
{
    float distToelementdivide = Vector3.Distance(ElementDivide.transform.position, (Element2v2.transform.position
    + Element1.transform.position) / 2);
    if (distToelementdivide < distance)
    {
        currentNumberCombination = DetermineNumberCombination12(Element2v2, Element1);
        if (currentNumberCombination != lastActivatedCombination)
        {
            ActivateAnswer12_3(currentNumberCombination);
            lastActivatedCombination = currentNumberCombination;
        }
        return;
    }
}

if (dsdm.isElementActive(Element1v2.name) && dsdm.isElementActive(Element2.name)&&
    dsdm.isElementActive(ElementDivide.name))
{
    float distToelementdivide = Vector3.Distance(ElementDivide.transform.position, (Element2.transform.position
    + Element1v2.transform.position) / 2);
    if (distToelementdivide < distance)
    {
        currentNumberCombination = DetermineNumberCombination12(Element2, Element1v2);
        if (currentNumberCombination != lastActivatedCombination)
        {
            ActivateAnswer12_3(currentNumberCombination);
            lastActivatedCombination = currentNumberCombination;
        }
        return;
    }
}
```

Figure 29: Code for Division

This code determines whether the element is active. The distance between Element-Plus, Element-Minus, Element-Times, Element-Divide and the middle of the first two elements is calculated if all are active. The equal sign (Equal-Sign) and the response display are activated if the distance is less than a predetermined threshold. In addition, if the response hasn't been engaged before, it plays an audio clip. The equal sign and the solution are positioned in relation to Element-Plus, Element-Minus, Element-Times, and Element-Divide. The response activation flag (isAnswerActivated) is reset and the equal sign and answer are disabled if the distance criterion is not satisfied.

4.4.3 Answer Checking

```
public void correct(GameObject option)
{
    Debug.Log("Correct answer!");
    PlayCorrectAnswerAudio(); // Play correct answer audio
    ScoreCount += 1;
    questionsAnswered++;
    option.GetComponent<Image>().color = Color.green; // Set button color to green
    StopTimer(); // Stop the timer when an answer is selected
    SetButtonsInteractable(false); // Disable buttons after selection
    StartCoroutine(NextQuestion()); // Delay before loading the next question
}

2 references
public void wrong(GameObject option)
{
    Debug.Log("Wrong answer.");
    PlayWrongAnswerAudio(); // Play wrong answer audio
    HighlightCorrectAnswer();
    questionsAnswered++;
    option.GetComponent<Image>().color = Color.red; // Set button color to red
    StopTimer(); // Stop the timer when an answer is selected
    SetButtonsInteractable(false); // Disable buttons after selection
    StartCoroutine(NextQuestion()); // Delay before loading the next question
}

3 references
IEnumerator NextQuestion()
{
    yield return new WaitForSeconds(1.5f); // Wait for 0.5 seconds before generating the next question
    ResetButtonColors(); // Reset the button colors before the next question
    GenerateQuestion();
}

void SetAnswers()
{
    for (int i = 0; i < options.Length; i++)
    {
        options[i].GetComponent<AnswerScript>().isCorrect = false;
        options[i].transform.GetChild(0).GetComponent<TextMeshProUGUI>().text = selectedQuestions[currentQuestionIndex].Answers[i];

        if (selectedQuestions[currentQuestionIndex].CorrectAnswers == i + 1)
        {
            options[i].GetComponent<AnswerScript>().isCorrect = true;
        }

        // Add button click event to pass the button itself
        Button btn = options[i].GetComponent<Button>();
        btn.onClick.RemoveAllListeners(); // Clear previous listeners to avoid duplicates
        if (options[i].GetComponent<AnswerScript>().isCorrect)
        {
            btn.onClick.AddListener(() => correct(options[i]));
        }
        else
        {
            btn.onClick.AddListener(() => wrong(options[i]));
        }
    }
}
```

Figure 30: Code for Answer Checking

The user interactions in a quiz game are managed by this code. Depending on whether the response is valid or incorrect, the ‘correct()’ or ‘wrong()’ function is called when an answer is selected. Both approaches record the outcome, play auditory feedback, halt the timer, prevent more

button presses, and alter the button's color (red for incorrect, green for right). After that, the game uses the 'NextQuestion()' coroutine to go to the next question, pausing for 1.5 seconds. The 'SetAnswers()' function adds listeners to handle answer selection, assigns answer possibilities to buttons, and sets the right answer.

4.4.4 Question Generated

```
void GenerateQuestion()
{
    if (questionsAnswered < questionCount)
    {
        currentQuestionIndex = Random.Range(0, selectedQuestions.Count);
        QuestionTxt.text = selectedQuestions[currentQuestionIndex].Questions;
        SetAnswers();
        selectedQuestions.RemoveAt(currentQuestionIndex);
        SetButtonsInteractable(true); // Enable buttons for the new question
        StartCoroutine(DelayedStartTimer(0.5f)); // Delay the start of the timer by 0.3 seconds
    }
    else
    {
        Debug.Log("Out of Question");
        GameOver();
    }
}

1 reference
IEnumerator DelayedStartTimer(float delay)
{
    yield return new WaitForSeconds(delay); // Wait for the specified delay
    ResetTimer(); // Start the timer after the delay
}

1 reference
void SelectRandomQuestions()
{
    List<int> indices = new List<int>();
    while (indices.Count < questionCount)
    {
        int randIndex = Random.Range(0, QnA.Count);
        if (!indices.Contains(randIndex))
        {
            indices.Add(randIndex);
            selectedQuestions.Add(QnA[randIndex]);
        }
    }
}
```

Figure 31: Code for Generation of Questions

The creation and presentation of random quiz questions is handled by this code. First, the 'GenerateQuestion()' function determines whether any questions remain unanswered. If so, it uses 'DelayedStartTimer()' to start the timer after a brief delay, chooses a question at random from the 'selectedQuestions' list, displays it, configures the answer options, and activates the buttons. In order to prevent duplication, the chosen question is then eliminated from the list. The 'GameOver()' function is triggered and "Out of Question" is logged if all questions are answered. By generating a list of distinct random indices, the

'SelectRandomQuestions()' function guarantees a random selection of questions. These indices are then utilized to append questions from the QnA pool to the 'selectedQuestions' list.

4.5 Presentation of Data

This pertains to demonstrating the operability of the proposed system. Functionality, Efficiency, Usability, Reliability, Maintainability, and Portability are the different basis for the review of the proposed system., evaluated by the following mark 1-5, 1–Unacceptable, 2–Moderately Acceptable, 3-Acceptable, 4-Very Acceptable, 5-Highly Acceptable (The Standard of Reference – ISO 25010).

Table 2

Evaluation of End-User

Criteria	Mean	Interpretation
Functionality	4.48	Very Acceptable
Efficiency	4.53	Highly Acceptable
Usability	4.62	Highly Acceptable
Reliability	4.55	Highly Acceptable
Maintainability	4.47	Very Acceptable
Portability	4.48	Very Acceptable
Overall Mean	4.52	Highly Acceptable

Table 3

Evaluation of Math Teachers

Criteria	Mean	Interpretation
Functionality	4.56	Highly Acceptable
Efficiency	4.78	Highly Acceptable
Usability	4.83	Highly Acceptable
Reliability	4.75	Highly Acceptable
Maintainability	4.33	Very Acceptable
Portability	4.67	Highly Acceptable
Total	4.65	Highly Acceptable

Table 4

Evaluation of IT-Experts

Criteria	Mean	Interpretation
Functionality	4.53	Highly Acceptable
Efficiency	4.67	Highly Acceptable
Usability	4.80	Highly Acceptable
Reliability	4.70	Highly Acceptable
Maintainability	5.00	Highly Acceptable
Portability	4.90	Highly Acceptable
Overall Mean	4.77	Highly Acceptable

Table 5

Evaluation of End-User, Math-Teachers, and IT-Experts

Criteria	Mean	Interpretation
Functionality	4.53	Highly Acceptable
Efficiency	4.61	Highly Acceptable
Usability	4.66	Highly Acceptable
Reliability	4.59	Highly Acceptable
Maintainability	4.58	Highly Acceptable
Portability	4.59	Highly Acceptable
Overall Mean	4.59	Highly Acceptable

4.6 Interpretation of Data

In table 2 it showed the summary of the weighted average from the end-user with an overall mean of 4.52, with the interpretation of Highly Acceptable; the highest mean is Usability 4.62; the application is user-friendly and effectively meets users' needs by providing an intuitive interface that facilitates easy learning, goal achievement, and an overall satisfying experience. Efficiency received 4.53; the application operates efficiently, with fast response times, optimal resource utilization, and sufficient capacity to meet all necessary requirements. Maintainability achieved 4.47; the application demonstrated stability by allowing modifications to one part without significantly affecting others while maintaining consistent performance without crashing. Reliability gets 4.55; the application

is reliable, readily accessible, performs as expected even with minor errors, and quickly recovers from any issues or bugs encountered during regular use. Portability scored 4.48, which means the application is easy to install and can be seamlessly installed on other Android devices. Functionality 4.48 is based on the end-user; the application consistently performs its intended functions, providing accurate results and helping users achieve their goals effectively.

In table 3 it shows the weighted average ratings for Math-Wonder as determined by math teachers. The system obtained an overall mean score of 4.65, which is translated as "Highly Acceptable." Of the categories, Usability received the highest mean of 4.83, suggesting that teachers found the system simple to use and comprehend. Efficiency was assessed at 4.78, indicating how effectively the system uses resources to complete tasks, allowing users to engage smoothly and without additional hassles. Maintainability, with a mean score of 4.33, showed the system is simple to maintain and troubleshoot should any problems develop. The system achieved a Reliability score of 4.75, indicating its ability to work consistently and dependably. Portability received a score of 4.67, indicating that math teachers value the system's flexibility, which allows it to be accessed and used from anywhere. Finally, math teachers gave Functionality a score of 4.56, stating that the system is well-suited to its goal, with a variety of features that efficiently assist instructional duties. Overall, Math-Wonder is well praised for its usefulness, efficiency, and dependability, making it a vital tool for improving the learning experience.

Equally important, table 4 displayed the overall mean from IT Experts in the system 4.77, and the interpretation is Highly Acceptable. The highest mean is Maintainability 5.00. The application demonstrated stability by allowing changes to one component with minimal impact on other components, while maintaining consistent performance. Portability got 4.90; the system demonstrates acceptable response and processing times, effectively utilizes resources to meet its requirements, adheres to maximum parameter limits, and can be easily installed on other Android mobile phones. Usability, achieved at a rate of 4.80; the system is well-suited to user needs, allowing specified users to achieve their learning goals effectively and efficiently while offering ease of operation and a user-friendly interface that facilitates enjoyable interactions. Reliability gained a rate of 4.70. The system meets reliability requirements under regular operation, remains accessible when needed, functions as intended despite minor faults, and quickly recovers from application errors or bugs. Efficiency got 4.67 because of the capacity of

user to engage with the system at any moment and any time, it is possible to enhance the utilization of resource while concurrently reducing periods of inactivity Functionality scored 4.53. The application successfully covers all specified tasks and user objectives, consistently delivering accurate results and fulfilling its intended functions.

In table 5 it showed the evaluation of the math AR app based on feedback from end-users, math teachers, and IT experts reveals a highly favorable overall assessment. Usability received the highest score of 4.66, categorizing it as "Highly Acceptable," reflecting that the application is user-friendly and effectively serves users' needs by providing an intuitive interface that enables easy learning, goal attainment, and an overall enjoyable experience. Both Reliability and Portability scored 4.59, also classified as “Highly Acceptable” highlighting confidence in the app's consistent performance and users can easily use it whenever they want. Maintainability scored 4.58, classified as “Highly Acceptable” presented that the users find the app could maintain in long run. And lastly Functionality was rated with a mean score of 4.53, indicating it is perceived as "Highly Acceptable." With an overall mean of 4.59, the AR app is viewed as "Highly Acceptable" across the evaluated criteria, demonstrating its potential as an effective tool for enhancing mathematics learning.

4.7 Project Evaluation

Table 6

Respondents of Evaluation

Respondents	Frequency	Percentage
End-Users	32	80%
Math Teachers	3	7.5%
IT-Experts	5	12.5%
Total	40	100%

In table 6 it shows the Project Evaluation system was used and evaluated by 32 users, 3 Math-Teachers, and 5 IT-Experts for a total of 40 Respondents. The purpose of the system presentation was to help the respondents understand the features and operation of the system. A questionnaire was provided to each respondent in order to figure out the features and methods of function of the system.

Table 7

Mean Distribution of End-User's Rating based on Functionality

Functionality	Mean	Interpretation
Functional Completeness	4.47	Very Acceptable
Functional Correctness	4.38	Very Acceptable
Functional Appropriateness	4.59	Highly Acceptable
Total	4.48	Very Acceptable

In table 7 it showed the General Weighted Mean of Functionality is 4.48 with the interpretation of Very Acceptable, the highest is 4.59 because the system are user friendly and suitable for any kind of users. For completeness got 4.47 mean because the system has its complete functions and usability for the users. Correctness got 4.38 mean because the system's accuracy in performing its intended tasks or function.

Table 8

Mean Distribution of End-User's Rating based on Efficiency

Efficiency	Mean	Interpretation
Time Behavior	4.50	Highly Acceptable
Resource Utilization	4.56	Highly Acceptable
Capacity	4.53	Highly Acceptable
Total	4.53	Highly Acceptable

In table 8 it showed the General Weighted Mean of 4.53 with the interpretation of Highly Acceptable, the highest mean is Resource Utilization 4.56 because the system with which users engage pertains to the effectiveness of resource management and allocation to facilitate user activities, Capacity 4.53 because the system has the capacity to do its intended task, Time Behaviour 4.50 optimizing the time behavior of a system is essential for delivering a positive and seamless user experience.

Table 9

Mean Distribution of End-User's Rating based on Usability

Usability	Mean	Interpretation
Appropriateness	4.53	Very Acceptable

Learnability	4.59	Highly Acceptable
Operability	4.66	Highly Acceptable
User Interface Aesthetics	4.69	Highly Acceptable
Total	4.62	Highly Acceptable

In table 9 it showed the General Weighted Mean of Usability is 4.62 with the interpretation of Highly Acceptable, the highest mean is User Interface Aesthetics 4.69 because the system has interactive design and very user-friendly that the user can enjoy it. Operability 4.66 and Learnability 4.59 because the system is very user-friendly, easy to learn and operate. Lastly Appropriateness got 4.53 because they can use it easy and it is suitable for any users.

Table 10

Mean Distribution of End-User's Rating based on Reliability

Reliability	Mean	Interpretation
Maturity	4.59	Highly Acceptable
Availability	4.69	Highly Acceptable
Fault tolerance	4.47	Very Acceptable
Recoverability	4.47	Very Acceptable
Total	4.55	Highly Acceptable

In table 10 showed the General Weighted Mean of Reliability is 4.55 with the interpretation of Highly Acceptable, the highest mean is Availability 4.69 because the system is always available and easy to access. Maturity scored 4.59, because the users can interact with the level of stability, reliability and completeness of the system's functionalities over time. Recoverability and Fault Tolerance both scored 4.47, because the user can recover the data inside of it and possessed the capability to sustain operation even in the event of system failure.

Table 11

Mean Distribution of End-User's Rating based on Maintainability

Maintainability	Mean	Interpretation
Modularity	4.50	Highly Acceptable

Modifiability	4.44	Very Acceptable
Total	4.51	Very Acceptable

In table 11 it showed the General Weighted Mean of Maintainability is 4.47 with the interpretation of Very Acceptable, Modularity 4.50 is the highest because the system enables a more adaptable and user-friendly system that can evolve over time to meet changing user requirements, enhancing the overall user experience. Modifiability 4.44 the user easily modified or adjusted to meet new needs, features, or advancements.

Table 12

Mean Distribution of End-User's Rating based on Portability

Portability	Mean	Interpretation
Adoptablity	4.47	Very Acceptable
Installability	4.50	Highly Acceptable
Total	4.48	Very Acceptable

In table 12 it showed the General Weighted Mean of Portability is 4.48 with the interpretation of Very Acceptable, Installability 4.50 is the highest mean because the user can easily install it, Adaptability got 4.47 because the system is easy to use so that the user can easily adopt and learn it.

Table 13

Mean Distribution of Evaluation of End-User

Criteria	Mean	Interpretation
Functionality	4.48	Very Acceptable
Efficiency	4.53	Highly Acceptable
Usability	4.62	Highly Acceptable
Reliability	4.55	Highly Acceptable
Maintainability	4.47	Highly Acceptable
Portability	4.48	Very Acceptable
Total	4.52	Highly Acceptable

In table 13 it displayed a summary of the weighted average from the end-user, with an overall mean of 4.52, interpreted as Highly Acceptable; the highest mean is Usability

4.62, indicating that the application is user-friendly and effectively meets users' needs by providing an intuitive interface that facilitates easy learning, goal achievement, and an overall satisfying experience. Efficiency earned 4.53; the program runs smoothly, optimal resource use, and enough capacity to meet all requirements. Maintainability was rated 4.47; the application displayed stability by allowing changes to one section without significantly affecting others while keeping constant performance. Reliability receives a 4.55 rating; the application is dependable, easily accessible, functions as expected even with minor mistakes, and swiftly recovers from any problems or defects found during regular use. Portability received a score of 4.48, indicating that the program is simple to install and can be effortlessly installed on other Android devices. Functionality 4.48 is user-centered; the application constantly executes its intended functions, producing accurate results and assisting users in effectively achieving their goals.

Table 14

Mean Distribution of Math Teacher's Rating based on Functionality

Functionality	Mean	Interpretation
Functional Completeness	4.67	Highly Acceptable
Functional Correctness	4.67	Highly Acceptable
Functional Appropriateness	4.33	Very Acceptable
Total	4.56	Highly Acceptable

In table 14 it showed the General Weighted Mean of Functionality is 4.56 with the interpretation of Highly Acceptable, the highest is 4.67 because the system has its complete functions and usability for the users and the system's accuracy in performing its intended tasks or function. For appropriateness got 4.46 mean because the system are user friendly and suitable for any kind of users.

Table 15

Mean Distribution of Math Teacher's Rating based on Efficiency

Efficiency	Mean	Interpretation
Time Behavior	4.67	Highly Acceptable
Resource Utilization	5.00	Highly Acceptable
Capacity	4.67	Highly Acceptable

Total	4.78	Highly Acceptable

In table 15 it showed the General Weighted Mean of 4.78 with the interpretation of Highly Acceptable, the highest mean is Resource Utilization 5.00 because the system with which users engage pertains to the effectiveness of resource management and allocation to facilitate user activities, Capacity 4.67 because the system has the capacity to do its intended task, Time Behaviour 4.54 optimizing the time behavior of a system is essential for delivering a positive and seamless user experience.

Table 16

Mean Distribution of Math Teacher's Rating based on Usability

Usability	Mean	Interpretation
Appropriateness	4.67	Highly Acceptable
Learnability	5.00	Highly Acceptable
Operability	4.67	Highly Acceptable
User Interface Aesthetics	5.00	Highly Acceptable
Total	4.83	Highly Acceptable

In table 16 it showed the General Weighted Mean of Usability is 4.83 with the interpretation of Highly Acceptable, the highest mean is User Interface Aesthetics and Learnability 5.00 because the system has interactive design and very user-friendly that the user can enjoy it and easy to learn. Operability and Appropriateness 4.67 because the system is very user-friendly, operate, and it is suitable for any users.

Table 17

Mean Distribution of Math Teacher's Rating based on Reliability

Reliability	Mean	Interpretation
Maturity	4.67	Highly Acceptable
Availability	5.00	Highly Acceptable
Fault tolerance	4.67	Highly Acceptable
Recoverability	4.67	Highly Acceptable
Total	4.67	Highly Acceptable

In table 17 it showed the General Weighted Mean of Reliability is 4.67 with the interpretation of Highly Acceptable, the highest mean is Availability 5.00 because the system is always available and easy to access. Maturity, Fault tolerance, and Recoverability got 4.67 because the users can interact with the level of stability, reliability and completeness of the system's functionalities over time, the system possessed the capability to sustain operation even in the event of system failure, and the user can recover the data inside of it.

Table 18

Mean Distribution of Math Teacher's Rating based on Maintainability

Maintainability	Mean	Interpretation
Modularity	4.33	Very Acceptable
Modifiability	4.33	Very Acceptable
Total	4.33	Very Acceptable

In table 18 it showed the General Weighted Mean of Maintainability is 4.33 with the interpretation of Very Acceptable, Modularity and Modifiability got the same 4.33 results, because the system enables a more adaptable and user-friendly system that can evolve over time to meet changing user requirements, enhancing the overall user experience, and the user easily modified or adjusted to meet new needs, features, or advancements.

Table 19

Mean Distribution of Math Teacher's Rating based on Portability

Portability	Mean	Interpretation
Adoptablity	4.67	Very Acceptable
Installability	4.67	Highly Acceptable
Total	4.67	Very Acceptable

In table 19 it showed the General Weighted Mean of Portability is 4.67 with the interpretation of Very Acceptable, Installability and Adaptability got the same results of 4.67, because the user can easily install it, and it is easy to use so that the user can easily adopt and learn it.

Table 20

Mean Distribution of Evaluation of Math Teachers

Criteria	Mean	Interpretation
Functionality	4.56	Highly Acceptable
Efficiency	4.78	Highly Acceptable
Usability	4.83	Highly Acceptable
Reliability	4.75	Highly Acceptable
Maintainability	4.33	Very Acceptable
Portability	4.67	Highly Acceptable
Total	4.65	Highly Acceptable

In table 20 it showed the summary of Math-Wonder's weighted average from math teachers with the overall mean of 4.65 with the interpretation of Highly Acceptable, the highest mean is Usability 4.83 because the system is easy to use and understand. Efficiency got 4.78 because the users can interact with refers to how effectively it utilizes resources to accomplish task. Maintainability got 4.33 because the system is easy to maintain in case of there is any problem. Reliability 4.75 the system has the quality of being reliable or performing consistently well. Portability 4.67 because system can engage and use it whenever where you are. Functionality 4.56 based on the respondent the quality of being suited the ability to engage with pertains to the variety and efficiency to serve a purpose well.

Table 21

Mean Distribution of IT Expert's Rating based on Functionality

Functionality	Mean	Interpretation
Functional Completeness	5.00	Highly Acceptable
Functional Correctness	4.20	Very Acceptable
Functional Appropriateness	4.40	Very Acceptable
Total	4.53	Highly Acceptable

In table 21 it showed the ratings of IT Experts based on Functionality of app, the General Weighted Mean is 4.53 and the interpretation is Highly Acceptable, the highest mean is Functional Completeness 5.00 because our app is accurate has its complete

functions and usability for the users. Functional Appropriateness 4.40 because it is a user-friendly and the function is suitable for the student who will use our app. Functional Correctness 4.20 Because ensuring effective resource distribution and management depends critically on optimizing the time behavior of the system with which users interact

Table 22

Mean Distribution of IT Expert's Rating based on Efficiency

Efficiency	Mean	Interpretation
Time Behavior	4.00	Very Acceptable
Resource Utilization	5.00	Highly Acceptable
Capacity	5.00	Highly Acceptable
Total	4.67	Highly Acceptable

In table 22 it showed the ratings of IT Experts based on Efficiency of app, the General Weighted Mean is 4.67 and the interpretation is Highly Acceptable. Resource Utilization and Capacity got the same mean of 5.00 because guaranteeing efficient resource distribution and management, enabling user engagements, and providing a favorable and uninterrupted user experience. Time behavior got 4.00 because ensuring effective resource resource and management depends critically on optimizing the time behavior of the system with which users interact.

Table 23

Mean Distribution of IT Expert's Rating based on Usability

Usability	Mean	Interpretation
Appropriateness	5.00	Highly Acceptable
Learnability	5.00	Highly Acceptable
Operability	4.60	Highly Acceptable
User Interface Aesthetics	4.60	Highly Acceptable
Total	4.80	Highly Acceptable

In table 23 it showed the ratings of IT Experts based on Usability of app, the General Weighted Mean is 4.80 and the interpretation is Highly Acceptable. The highest mean are Appropriateness and Learnability 5.00 because our app is suitable and relevant for the intended purpose also because our app is easy to learn for the students. Operability

and User Interface Aesthetics 4.60 because the UI of it is very interactive for the young learners and they can operate it easily.

Table 24

Mean Distribution of IT Expert's Rating based on Reliability

Reliability	Mean	Interpretation
Maturity	5.00	Highly Acceptable
Availability	4.60	Highly Acceptable
Fault tolerance	4.40	Very Acceptable
Recoverability	4.80	Highly Acceptable
Total	4.70	Highly Acceptable

In table 24 it showed the ratings of IT Experts based on Reliability of app, the General Weighted Mean is 4.70 and the interpretation is Highly Acceptable. The highest mean is Maturity 5.00 because Users have the ability to engage with the system's functionalities in terms of stability, reliability, and completeness as time progresses. Recoverability 4.80 because the system's guaranteed by its continuous availability and its capability to retrieve data stored within it. Availability 4.60 because users have the ability to use it whenever where they are and it is very convenient for them. Fault Tolerance 4.40 because the system's capacity to sustain operation, despite encountering failure.

Table 25

Mean Distribution of IT Expert's Rating based on Maintainability

Maintainability	Mean	Interpretation
Modularity	5.00	Highly Acceptable
Modifiability	5.00	Highly Acceptable
Total	5.00	Highly Acceptable

In table 25 it showed the ratings of IT Experts based on Maintainability of app, the General Weighted Mean is 5.00 and the interpretation is Highly Acceptable. Modularity and Modifiability got the same mean of 5.00 because it improves the overall user experience, it fosters a highly adaptive and user-friendly system that can change to fit the demands of the user. Users may quickly modify or adjust the system to accommodate new features, improvements, or requirements.

Table 26

Mean Distribution of IT Expert's Rating based on Portability

Portability	Mean	Interpretation
Adoptablity	4.80	Highly Acceptable
Installability	5.00	Highly Acceptable
Total	4.90	Highly Acceptable

In table 26 it showed the ratings of IT Experts based on Portability of app, the General Weighted Mean is 4.90 and the interpretation is Highly Acceptable. Installability got the highest mean of 5.00 because our app is easy to install for teachers, less hassle and less time consuming. Adoptability 4.80 because the user can easily adapt to this new environment of learning and they can easily learn it.

Table 27

Mean Distribution of Evaluation of IT Expert

Criteria	Mean	Interpretation
Functionality	4.53	Highly Acceptable
Efficiency	4.67	Highly Acceptable
Usability	4.80	Highly Acceptable
Reliability	4.70	Highly Acceptable
Maintainability	5.00	Highly Acceptable
Portability	4.90	Highly Acceptable
Total	4.77	Highly Acceptable

In table 27 it showed the overall mean from IT Experts in the system 4.77 and the interpretation is Highly Acceptable. The highest mean is Maintainability 5.00 because our app is easy to maintain in case of there is any problem. Portability 4.90 because of the system's capacity for user engagement pertains to its effective use of resources in achieving objectives, guaranteeing involvement and availability regardless of location or time. Usability 4.80 because of our app is easy to operate and very user-friendly. Reliability 4.70 because the app is reliable and useful for the student who will use it. Efficiency 4.67 because users can interact with the system anytime and from anywhere, optimizing resource use and minimizing downtime. Functionality 4.53 because of the characteristic of

being appropriate pertains to the capacity to interact effectively with various aspects and to efficiently fulfil a given purpose.

Table 28

Evaluation of End-User, Math Teachers, and IT-Experts

Criteria	Mean	Interpretation
Functionality	4.53	Highly Acceptable
Efficiency	4.61	Highly Acceptable
Usability	4.66	Highly Acceptable
Reliability	4.59	Highly Acceptable
Maintainability	4.58	Highly Acceptable
Portability	4.59	Highly Acceptable
Overall Mean	4.59	Highly Acceptable

In table 28 it showed the evaluation of the math AR app based on feedback from end-users, math teachers, and IT experts reveals a highly favorable overall assessment. Usability achieved the highest score of 4.66, indicating that the application is extremely user-friendly, with an intuitive UI that not only fits users' demands but also promotes a pleasurable and accessible learning experience. This score shows how well the software facilitates easy navigation, goal accomplishment, and a positive user experience, making it appropriate for users of all ages and technical skills. Users' confidence in the app's consistent performance and versatility, as it can be used at any time and from any location, was reflected in its reliability and portability scores of 4.59 each. This flexibility enables continued learning regardless of location, increasing the app's usefulness as a mobile learning tool. Maintainability obtained a score of 4.58, indicating that the program is simple to maintain; customers value its stability, and faults can be fixed with little effort. Functionality, with a mean score of 4.53, demonstrates that the app efficiently serves educational goals by delivering appropriate features and material that contribute to its function as a learning tool. With an overall mean rating of 4.59, the AR software is rated "Highly Acceptable" across all parameters, demonstrating its potential as a powerful and practical tool for improving mathematics learning and engagement.

5.0 Summary of Findings, Conclusion, and Recommendation

5.1 Summary of Findings

The results show that many youngsters still struggle with basic math's. The Math-Wonder system has been quite successful in helping this group of people with their mathematics education by using Augmented Reality (AR). With the use of this state-of-the-art technology, teachers may offer a fun and creative substitute for conventional teaching methods, which has been beneficial in enhancing students' understanding of mathematical concepts. Teachers have noted that this method makes it easier to explain mathematical problems in a way that is more visually appealing and intriguing, which increases student engagement and makes the learning process more dynamic.

Furthermore, the use of interactive three-dimensional visuals that students may view and control with their mobile devices makes abstract mathematical ideas participatory as well as accessible. In addition to holding students' interest, this immersive and interactive approach greatly improves their understanding and memory of mathematical concepts. Additionally, the Math-Wonder system is a great supplemental resource that gives students access to extra resources to enhance their education outside of traditional classroom settings. By providing a stimulating and interactive modality for the study of mathematics, this approach cultivates students' self-efficacy regarding their mathematical capabilities and mitigates their apprehension regarding the subject matter. Educators have observed an increasing willingness among students to engage with the content, resulting in a more favorable disposition toward mathematics as a whole.

Reviews of the system have generally been favorable. Users express great pleasure, saying that the system often meets or exceeds their expectations. Feedback suggests that in addition to being an important teaching tool, Math-Wonder also offers a potential solution to the persistent problems faced by beginning students in the field of mathematics. Its efficacy, user involvement, and favorable feedback suggest that the system has the potential to make a significant impact on mathematics education by providing kids with the necessary tools to succeed academically.

5.2 Conclusion

Math-wonders has been acknowledged as an essential tool for teaching mathematics, markedly enhancing student academic performance. Learners who engaged in this methodology perceived arithmetic as more approachable and enjoyable, resulting in a heightened interest in the subject. This innovative approach not only enhanced instructional effectiveness but also provided students with a modern, engaging way to learn and master mathematical concepts. Through the integration of interactive components and pragmatic applications, math-wonders cultivates a more profound comprehension of mathematics, thereby equipping students with the competency's requisite for future achievements.

Furthermore, educators have reported enhanced classroom dynamics and an increase in collaborative efforts among students as a consequence of this groundbreaking methodology. Math-wonder's overall evaluation score by end-users was highly acceptable, with an overall weighted mean of 4.52, a highly acceptable rate by Math teachers, with an overall weighted mean of 4.65, and IT experts, with an overall weighted mean of 4.77. It means that the program works well on Android devices, is easy to adapt and use, and has shown to be beneficial and successful based on respondents and IT experts' evaluation, the system was well regarded which supports its potential as an important teaching tool. It concludes that the mobile application is functional, performance efficient, compatible, usable, reliable, maintainable, and portable. Overall, educators discovered that enhancing their methods greatly shortened the amount of time needed to explain difficult ideas since students were able to grasp them more quickly and intuitively thanks to the incorporation of visual aids.

In addition to making complex concepts easier to understand, these visual aids increased student participation and made the learning process more dynamic. The development of educational technology enabled educators to adapt their lessons to the various learning requirements of their students, resulting in more effective and efficient course delivery. Teachers could better accommodate different learning styles and make sure all students got the help they needed to understand difficult subject by utilizing these cutting-edge tools. As a result, learning became more enjoyable and fulfilling for both teachers and students

5.4 Recommendations

A series of important recommendations are proposed for future researchers to enhance both the instructional efficacy and user engagement of the Math-Wonders program.

The beneficiary must use the proposed system to confirm that it properly meets their individual needs and criteria. By interacting directly with the technology, the beneficiary will be able to test its functionality, evaluate its usability, and provide vital feedback for future enhancement.

For future development of the program, it is recommended that the significant improvements to the graphical user interface (GUI) should be prioritized. Implementing more dynamic display transitions when answers are presented will create a more interactive and captivating experience for students. Features such as animations that celebrate correct answers or visually guide students through problem-solving processes can make learning more enjoyable and rewarding.

To better cater to higher grade levels, it is essential to add more advanced mathematics lessons that cover a broader range of topics, including fractions, decimals, ratios, and introductory algebra. This expansion will provide students with the opportunity to explore various mathematical areas, ensuring they develop a well-rounded understanding of the subject.

Moreover, ensuring compatibility with iOS devices will broaden accessibility, allowing a wider range of students to benefit from the learning tool and facilitating a more inclusive educational experience.

Finally, it is advised to include a 2D analog clock function in order to improve the application's instructional value. Users should be able to rotate or drag the hour and minute hands on this clock, giving them a hands-on experience with time telling. Furthermore, by adding voice or audio feedback, users will be able to hear the corresponding time, strengthening their learning through both aural and visual signals.

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Appendices

Appendix A

Work Breakdown Structure (WBS)

Math-Wonders: Augmented Reality Flashcards using Image Recognition Algorithm for Enhanced Children's Learning

Activity	Duration	Assigned Members
1.0 Plan and Identifying Requirements		
1.1 Determine the Beneficiaries	2 weeks	All Members
1.2 Identifying the Needs	2 weeks	Grimaldo & Mendoza
1.3 Gathering Information	2 weeks	Mollida & Tayam
1.4 Listing the Objectives	1 week	All Members
1.5 Tool Up	1 week	Mollida & Tayam
2.0 Design the Project		
2.1 Build GUI for Mobile App	1 month	Mollida & Tayam
2.3 Design Flashcards	1 month	Mollida & Tayam
3.0 System Develop		
3.1 Create 3D Numbers for AR	3 months	Mollida & Tayam
3.2 Integrating Voice in App	2 months	Mollida & Tayam
4.0 System Testing		
4.1 Beta Testing	1 month	All Members
5.0 Review and Improve the Project		
5.1 Fixed Errors or Bugs	1 month	Mollida & Tayam
5.2 Software Upgrade	1 month	Mollida & Tayam
6.0 Launch the Project		
6.1 Presentation of the Project	1 month	All Members
7.0 Documentation		
7.1 Writing Chapter 1 to Chapter 5	10 months	All Members

Appendix B

Gannt Chart

Math-Wonders: Augmented Reality Flashcards using Image Recognition Algorithm for Enhanced Children's Learning

Math-Wonders: Augmented Reality Flashcards Using Image Recognition Algorithm for Enhanced Children's Learning				2024					2024				
Phases	Activity	Start Date	End Date	Feb	Mar	Apr	May	Jun	Aug	Sept	Oct	Nov	Dec
1	Plan and identify requirements of the proje	Feb	Mar										
2	Design the project	Apr	May										
3	System Develop	Apr	Sept										
4	System Testing	Oct	Oct										
5	Review and Improve the project	Nov	Dec										
6	Launch the project	Dec	Dec										
7	Documentation	Feb	Dec										

Appendix C

Budget Plan

Math-Wonders: Augmented Reality Flashcards using Image Recognition Algorithm for Enhanced Children's Learning

Budget Plan	
Items	Price (Peso)
1. Software:	
• Vuforia	Free
• Unity Student Plan	Free
• Inkscape	Free
• Blender 3D	Free
• Canva Pro	2,500
2. Hardware:	
• Laptop	51,000
• Phone	10,000
3. Miscellaneous:	
• Sticker Paper	400
• Cutting Board	150
• Velum Board	150
• Box	100
4. Electricity	4,500
5. Internet Connection	2,000
Total	**70,800**

Appendix D

Survey Questionnaire

Math-Wonders: Augmented Reality Flashcards Using Image Recognition Algorithm for Enhanced Children's Learning

Dear Respondent,

Your cooperation by completing this form will make an important contribution in gathering a reliable and accurate data needed in development of the system. Rest assured that the information you give would be treated with utmost confidentiality as necessary.

Name (Optional): _____ Date: _____

Instruction: Using the given scale place a check mark (✓) under the corresponding numerical rating:

Numerical Rating		**Equivalent**
4	-	Strongly Agree
3	-	Agree
2	-	Disagree
1	-	Strongly Disagree

	4	**3**	**2**	**1**
1. To what extent do you agree or disagree that grade 2 students in school face challenges or difficulties in learning mathematics?				
2. To what extent do you agree or disagree that grade 2 students find it challenging to solve math problems on their own?				
3. To what extent do you agree or disagree that grade 2 student require additional support explanations or grasp basic math concepts				
4. To what extent do you agree or disagree that grade 2 students struggle to memorize basic math facts, such as addition and subtraction tables?				
5. To what extent do you agree or disagree that grade 2 students struggle to keep up with the pace of math lessons?				
6. To what extent do you agree or disagree that grade 2 students would be motivated to learn				

math if augmented reality were included in lessons?				
7. To what extent do you agree or disagree that using augmented reality flashcards would make math more engaging for grade 2 students?				
8. To what extent do you agree or disagree that augmented reality flashcards would provide grade 2 students with a more hands-on learning experience in math?				
9. To what extent do you agree or disagree that Augmented Reality Flashcards will positively impact students' understanding of mathematical concepts?				
10. To what extent do you agree or disagree that students would use Augmented Reality Flashcards as a tool for learning mathematics?				

Appendix E

Evaluation Instrument

Math-Wonders: Augmented Reality Flashcards Using Image Recognition Algorithm for Enhanced Children's Learning

Group Member's Name: Mendoza, Luke Aldrin V., Mollida, Juan Alfonso S., Grimaldo, Raymond Irhan F., Tayam, John Emmanuel E.

Dear Respondent,

This survey will serve as an instrument to assess the level of acceptability of the developed system. Your cooperation by completing this form will make an important contribution in gathering a reliable and accurate data needed in the evaluation of the developed system. Rest assured that the information you give would be treated with utmost confidentiality as necessary.

-

Proponents **Instruction:** Please evaluate the developed system by using the given scale and placing a check mark (✓) under the corresponding numerical rating:

Numerical Rating		Equivalent
5	-	Highly Acceptable
4	-	Very Acceptable
3	-	Acceptable
2	-	Moderately Acceptable
1	-	Unacceptable

Characteristics	Sub-Characteristics	Descriptions	5	4	3	2	1
Functionality	Functional Completeness	The application covers all the specified tasks and the user objectives					
	Functional Correctness	The application provides accurate results					
	Functional Appropriateness	The application accomplishes specified tasks and objectives					
Efficiency	Time Behaviour	The system has acceptable response and processing time and throughout rates					
	Resource Utilization	The resources used by a system, when performing the functions and meet its requirements					
	Capacity	The maximum limits of the system parameter meet the requirements					
Usability	Appropriateness	The system is appropriate for the user needs					
	Learnability						

		The system can be used by specified users to achieve specified goals of learning to use the system with effectiveness and efficiency					
	Operability	The system is easy to operate and control					
	UserInterface Aesthetics	The user interface enables pleasing and satisfying interaction for the user					
Reliability	Maturity	The system meets the needs for reliability under normal operation					
	Availability	The system is operational and accessible when required for use accessible					
	Fault Tolerance	The system operates as intended despite the presence of application faults					
	Recoverability	The system can recover easily after the application faults or bugs					
Maintainability	Modularity	The application has an ability to change to one component and has minimal impact on other components					
	Modifiability	The application has an ability to be stable					
Portability	Adaptability	The application can install in another android mobile phone and tablets					
	Installability	The application can easily install					

Instructions: Please fill up all the fields with * as required, optional otherwise.

Please confirm your response by signing. Thank you very much for your time and insights.

Respondent's Name:	
***Type of Respondent:**	☐ End User (Students / Teachers / Engineers) ☐ IT Experts (Software Developer / Programmer / Professionals)
Bachelor's Degree:	
Year Graduated:	
*Signature:	

Math-Wonders: Augmented Reality Flashcards Using Image Recognition Algorithm for Enhanced Children's Learning

Group Member's Name: Luke Aldrin V. Mendoza, Juan Alfonso S. Mollida, Raymond Irhan F. Grimaldo, John Emmanuel E. Tayam

Dear Respondent,

This survey will serve as an instrument to assess the level of acceptability of the developed system. Your cooperation by completing this form will make an important contribution in gathering a reliable and accurate data needed in the evaluation of the developed system. Rest assured that the information you give would be treated with utmost confidentiality as necessary.

Name (Optional): _____ Date: _____

Likert Scale Questionnaire

Instructions: Kindly evaluate the system by placing a check mark (✓) under the column indicating how strongly you agree or disagree with each corresponding question

Numerical Rating		Equivalent
5	-	Highly Acceptable
4	-	Very Acceptable
3	-	Acceptable
2	-	Moderately Acceptable
1	-	Unacceptable

Evaluation according to Functionality

Questions	5	4	3	2	1
1. The application does everything it is supposed to do and helps the user reach their goals.					
2. The application gives correct answers every time.					
3. The application completes all the tasks and goals it is designed to do.					

Evaluation according to Efficiency

Questions	5	4	3	2	1
1. The application works fast enough, with quick responses and smooth processing.					
2. The application uses the right number of resources to do its tasks and meet its needs.					
3. The application's limits are high enough to meet all the needs.					

Evaluation according to Usability

Questions	5	4	3	2	1
1. The application fits the user's needs well.					
2. The application helps users learn how to use it easily and reach their learning goals effectively and quickly.					
3. The application is simple to use and easy to manage.					
4. The user interface makes it enjoyable and satisfying for users to interact with the application.					

Evaluation according to Reliability

Questions	5	4	3	2	1
1. The application works reliably during regular use.					
2. The application is ready to use and easy to access whenever needed.					
3. The application works as expected even when there are some small errors.					
4. The application can quickly bounce back after facing any errors or bugs.					

Evaluation according to Reliability

Questions	5	4	3	2	1
1. The application can change one part without affecting the other parts much.					
2. The application is able to stay stable and not crash					

Evaluation according to Reliability

Questions	5	4	3	2	1
1. The application can be installed on other Android phones and tablets.					
2. The application is easy to install					

Appendix F

Summary (Tally) of Evaluation Result

Evaluator	Functionality			Efficiency			Usability				Reliability				Maintainability		Portability	
1	5	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
2	5	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
3	5	4	5	5	5	4	5	5	4	5	5	5	5	5	5	5	5	5
4	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6	5	4	5	5	4	5	4	5	4	5	4	5	4	5	5	4	5	5
7	4	4	5	4	4	4	5	4	4	5	4	5	5	5	4	5	4	4
8	4	5	5	4	5	5	4	4	4	5	4	4	4	4	5	4	4	4
9	5	2	5	4	4	5	5	5	5	4	5	4	5	4	5	4	5	4
10	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
11	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
12	5	4	4	5	5	5	4	5	4	5	4	5	5	4	5	5	4	5
13	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
14	4	5	4	4	5	5	4	5	5	4	5	5	4	4	4	5	5	5
15	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5
16	4	5	5	4	5	5	5	5	4	5	5	5	5	5	4	5	5	5
17	5	5	5	5	4	4	4	5	5	5	5	5	5	5	5	5	5	5
18	4	4	4	4	4	5	5	5	5	5	5	5	4	4	4	4	4	5
19	4	4	4	4	5	4	5	5	5	5	4	4	4	4	5	5	5	5
20	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	5
21	5	5	5	4	4	4	5	5	5	5	5	5	5	4	5	5	5	5
22	4	4	4	5	5	5	5	4	5	5	5	4	4	4	5	4	4	5
23	4	4	4	4	5	4	4	5	4	4	4	4	4	4	4	4	4	4
24	5	4	5	5	4	5	4	4	5	4	4	4	5	4	5	4	5	4
25	4	4	4	5	5	4	4	4	4	4	5	4	4	5	4	4	4	4
26	4	4	4	4	5	5	5	5	5	4	4	4	5	5	5	4	4	4
27	5	5	5	5	4	4	4	4	5	5	4	4	4	4	4	5	5	5
28	5	5	5	5	5	5	4	4	4	4	4	5	4	4	4	4	4	4
29	5	5	5	5	5	4	4	5	5	5	5	4	4	4	5	4	4	5
30	4	4	5	4	5	4	4	5	5	5	5	5	4	4	4	4	4	5
31	4	4	5	5	4	5	5	5	5	4	4	4	4	4	5	4	5	4
32	4	4	4	4	5	4	5	4	5	5	4	4	4	5	4	5	4	5
33	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
34	4	4	5	4	4	5	4	5	4	4	4	5	5	4	4	4	5	4
35	4	4	4	5	5	4	4	5	5	5	5	5	4	4	4	4	4	5
Total	4.46	4.40	4.57	4.54	4.71	4.66	4.51	4.51	4.60	4.69	4.57	4.54	4.43	4.46	4.54	4.40	4.43	4.54
Descriptive Evaluation	VERY ACCEPTABLE	VERY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	VERY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	VERY ACCEPTABLE	HIGHLY ACCEPTABLE	VERY ACCEPTABLE	VERY ACCEPTABLE	HIGHLY ACCEPTABLE
Average Mean	**4.48**			**4.64**			**4.53**				**4.50**				**4.51**		**4.49**	
Descriptive Evaluation	VERY ACCEPTABLE			HIGHLY ACCEPTABLE			HIGHLY ACCEPTABLE				HIGHLY ACCEPTABLE				HIGHLY ACCEPTABLE		VERY ACCEPTABLE	
Overall Mean	4.52																	
Descriptive Evaluation	HIGHLY ACCEPTABLE																	

End-Users

Evaluator	Functionality			Efficiency			Usability				Reliability				Maintainability		Portability	
1	5	4	5	4	5	5	5	5	5	4	5	5	4	5	5	5	5	5
2	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
3	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5
4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5
5	5	4	4	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5
Total	5.00	4.80	4.80	5.00	5.00	5.00	5.00	5.00	4.80	4.80	5.00	4.80	4.80	4.80	5.00	5.00	4.80	5.00
Descriptive Evaluation	HIGHLY ACCEPTABLE	VERY ACCEPTABLE	VERY ACCEPTABLE	VERY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	VERY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE
Average Mean	**4.53**			**4.67**			**4.80**				**4.70**				**5.00**		**4.90**	
Descriptive Evaluation	HIGHLY ACCEPTABLE			HIGHLY ACCEPTABLE			HIGHLY ACCEPTABLE				HIGHLY ACCEPTABLE				HIGHLY ACCEPTABLE		HIGHLY ACCEPTABLE	
Overall Mean	4.77																	
Descriptive Evaluation	HIGHLY ACCEPTABLE																	

Math-Teachers

Evaluator	Functionality			Efficiency			Usability				Reliability				Maintainability		Portability	
1	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
2	5	4	4	4	5	5	4	5	4	5	4	5	5	4	4	4	5	4
3	4	5	5	5	5	4	5	5	5	5	5	5	4	5	4	4	4	5
Total	4.67	4.67	4.33	4.67	5.00	4.67	4.67	5.00	4.67	5.00	4.67	5.00	4.67	4.67	4.33	4.33	4.67	4.67
Descriptive Evaluation	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	VERY ACCEPTABLE	VERY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	VERY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	VERY ACCEPTABLE	VERY ACCEPTABLE	HIGHLY ACCEPTABLE	VERY ACCEPTABLE	VERY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE
Average Mean	**4.56**			**4.78**			**4.83**				**4.75**				**4.33**		**4.67**	
Descriptive Evaluation	HIGHLY ACCEPTABLE			HIGHLY ACCEPTABLE			HIGHLY ACCEPTABLE				HIGHLY ACCEPTABLE				VERY ACCEPTABLE		HIGHLY ACCEPTABLE	
Overall Mean	4.65																	
Descriptive Evaluation	HIGHLY ACCEPTABLE																	

IT-Expert

Evaluator	Functionality			Efficiency			Usability				Reliability				Maintainability		Portability	
1	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
2	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
3	5	4	5	5	5	4	5	5	4	5	5	5	5	5	5	5	5	5
4	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6	5	4	5	5	4	5	4	5	5	5	4	5	4	5	5	4	5	5
7	4	4	5	4	4	4	5	4	4	5	4	5	5	5	4	5	4	4
8	4	5	5	4	5	5	4	4	5	5	4	4	4	4	5	4	4	4
9	5	2	5	4	4	5	3	5	5	4	5	4	5	4	5	4	5	4
10	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
11	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5
12	5	4	4	3	4	5	4	5	4	5	4	5	5	4	5	5	4	5
13	4	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5
14	4	5	4	4	5	4	4	5	5	4	5	5	4	4	4	5	5	5
15	5	5	5	5	4	5	5	4	5	5	5	5	5	5	5	5	5	5
16	4	5	5	4	5	5	5	5	4	5	5	5	5	5	4	5	5	5
17	5	5	5	5	4	4	4	5	5	5	5	5	5	5	5	5	5	5
18	4	4	4	4	4	5	3	3	5	5	5	5	4	4	4	4	4	5
19	4	4	4	4	5	4	5	5	5	5	4	4	4	4	5	5	5	5
20	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	5
21	5	5	5	4	4	4	5	5	5	5	5	5	4	4	4	5	5	5
22	4	4	4	5	5	5	4	5	5	5	5	4	4	4	5	4	4	5
23	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4
24	3	4	3	5	4	5	4	4	3	4	4	5	3	4	3	4	3	4
25	4	4	4	5	5	4	4	4	4	4	3	4	4	3	4	4	4	4
26	4	4	4	4	5	5	5	5	5	4	4	5	5	5	5	4	4	4
27	5	5	5	5	4	4	4	4	3	3	4	4	4	4	4	3	3	3
28	5	5	5	5	5	5	5	4	4	4	5	5	4	4	4	4	4	4
29	5	5	5	5	5	4	5	3	5	5	5	4	4	4	5	4	4	5
30	4	4	5	4	5	4	4	5	5	5	5	5	4	4	4	4	4	3
31	4	4	5	5	4	5	5	5	5	4	4	4	4	4	5	4	5	4
32	4	4	4	4	5	4	5	4	5	5	4	4	4	5	4	5	4	5
33	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
34	5	4	4	4	5	5	4	5	4	5	4	5	5	4	4	4	5	4
35	4	5	5	5	5	4	5	5	5	5	5	5	4	5	4	4	4	5
36	5	4	5	4	5	5	5	5	5	4	5	5	4	5	5	5	5	5
37	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
38	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5
39	5	3	3	3	5	5	5	5	5	5	5	5	3	5	5	5	4	5
40	5	4	4	3	5	5	5	5	3	5	5	3	5	4	5	5	5	5
Total	4.58	4.43	4.60	4.48	4.70	4.65	4.60	4.58	4.65	4.70	4.65	4.70	4.48	4.53	4.60	4.55	4.53	4.65
Descriptive Evaluation	HIGHLY ACCEPTABLE	VERY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE	HIGHLY ACCEPTABLE
Average Mean	**4.53**			**4.61**			**4.66**				**4.59**				**4.58**		**4.59**	
Descriptive Evaluation	HIGHLY ACCEPTABLE			HIGHLY ACCEPTABLE			HIGHLY ACCEPTABLE				HIGHLY ACCEPTABLE				HIGHLY ACCEPTABLE		HIGHLY ACCEPTABLE	
Overall Mean	4.59																	
Descriptive Evaluation	HIGHLY ACCEPTABLE																	

End-Users and IT Expert

Appendix G

Proof of Evaluation

Appendix H

Letter of Request to Conduct Research

OUR LADY OF FATIMA UNIVERSITY

COLLEGE OF COMPUTER STUDIES

Tamarraw Hills, Valenzuela City

DEPED VALENZUELA
RECORDS
RECEIVED
SEP 09 2024
24-B-259
BY: AS TIME: 10:45

July 31, 2024

Noel D. Bagano
Assistant School Division Superintendent Officer-in-Charge
Office of the Schhools Division Superintendent

Greetings!

We are the student of Our Lady of Fatima University – Valenzuela Campus, from Bachelor of Science in Computer Science are looking for prospective professional entity which we can offer our Thesis Project.

Our Thesis Project entitled **"MATH-WONDERS: Augmented Reality Flashcards Using Image Recognition Algorithm for Enhanced Children's Learning"** is an Augmented Reality, a supplementary application aims to help grade two student learn about basic mathematics in a certain school in Valenzuela City. The application content contains the number counting (ranges from zero to ninety-nine), basic mathematical operations (Addition, Subtraction, Multiplication, and Division), and basic geometric shapes.

We researchers are asking for a request to be allowed to conduct research in Tagalag Elementary School. Our target respondents in this research are grade 2 pupils. We do not ask for sensitive information from children, the only thing we ask of them is to evaluate our system application. After we accomplished our Thesis project, the researchers will give the system application to Tagalag Elementary School.

OUR LADY OF FATIMA UNIVERSITY

COLLEGE OF COMPUTER STUDIES

Tamarraw Hills, Valenzuela City

We are looking forward to hear the positive response on this humble matter. Your approval to conduct this study will be highly appreciated. For further questions, you may contact us and email us:

John Emmanuel E. Tayam – Principal Investigator in Thesis
09156514733 | jettayam01122@gmail.com

Thank you for your time and God Bless!

Respecfullly,

John Emmanuel E. Tayam
Principal Investigator

Luke Aldrin V. Mendoza
Programmer – Backend

Juan Alfonso S. Mollida
Programmer – Frontend

Walfredo G. Santos MSIT, MA Ed
CCS-Val Research Coordinator
College of Computer Studies
Our Lady of Fatima University

Raymond Irhan **F. Grimaldo**
Documents - Thesis

Republic of the Philippines
Department of Education
NATIONAL CAPITAL REGION
SCHOOLS DIVISION OFFICE OF VALENZUELA CITY

DEPED VALENZUELA RECORDS RELEASED
SEP 12 2024
24-R-259-A
BY: TIME: 11:54

September 11, 2024

John Emmanuel E. Tayam
Researcher/Principal Investigator in Thesis
Our Lady of Fatima University – Valenzuela Campus

Dear **Mr. Tayam:**

In response to your letter request dated September 9, 2024, this Office hereby grants permission to conduct your research entitled: **"MATH-WONDERS: Augmented Reality Flashcards Using Image Recognition Algorithm for Enhanced Children's Learning"** on conditions that:

1. content of **DepEd Order No. 9 s.2005** titled **"Instituting Measures to Increase Engaged Time-On-Task and Ensuring Compliance Therewith,"** shall be strictly observed;
2. ethical considerations related to the conduct of the research shall be strictly observed as stipulated in **DepEd Order No. 16, s. 2017, Research Management Guidelines;**
3. the conduct of the study shall not interrupt the regular program of the schools, with the teaching duties of the teachers and, will not disrupt regular classes;
4. resources of the school shall not be used for the said purpose; and
5. this Office shall be furnished with a copy of the findings and recommendations of the research.

Please be guided accordingly.

Very truly yours,

NOEL D. BAGANO
Assistant Schools Division Superintendent
Officer-in-Charge
Office of the Schools Division Superintendent

sgod/rpd/09-11-24

Address: Pio Valenzuela St., Marulas, Valenzuela City
Telephone Nos.: (02) 8293-4507, 8277-4648, 8291-0873, 8277-3439
Email Address: sdovalenzuela@deped.gov.ph
Official Website: https://www.sdovalenzuelacity.deped.gov.ph

OUR LADY OF FATIMA UNIVERSITY
COLLEGE OF COMPUTER STUDIES

Assent Form for Participation in Thesis Study

Title of the study / ***Paksa ng pag-sasaliksik***: **MATH-WONDERS: Augmented Reality Flashcards Using Image Recognition Algorithm for Enhanced Children's Learning**

Persons in contact for the study / ***Taong maaring tanungin patungkol sa pag-sasaliksik na ito***:

John Emmanuel E. Tayam
BS Computer Science – Student
Our Lady of Fatima University
Contact: 09156514733

Greetings to Parent/Guardian,

We, the researchers, are conducting a study to help kids learn mathematics in an easier way by creating a supplementary tool application. The tool contains specific topics in mathematics that they are currently learning, such as counting numbers, exploring basic shapes/geometry, and solving basic operations like addition, subtraction, multiplication, and division.

We encourage your child to participate in our study with parental/guardian consent. In the study conducted, a survey form will be provided for them asking about the application's performance based on their usage. The researchers will not ask for any confidential information. All the gathered information data will be protected and used for this study only. Participating in this study is entirely voluntary and does not provide any benefits. The research will be conducted on **(month)** Sept **(date)** 20 **, 2024**

We the researchers will respect the decision of parent/guardian if they wish not to participate a child in this study.

Paghati sa mga Magulang / Guardian ng bata,

Kami ng mga mananaliksik ay nagsasagawa ng isang pag-aaral upang matulungan ang mga bata na matutunan ang matematika sa mas madaling paraan sa pamamagitan ng paglikha ng application gamit ang teknolohiya. Ang aplication na ito ay naglalaman ng ilang partikular na paksa sa paksang matematika na kasalukuyang pinag-aaralan nila gaya ng paghihilang ng mga numero, paggalugad ng mga pangunahing hugis /

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COLLEGE OF COMPUTER STUDIES

geometry, paglutas ng mga pangunahing operasyon tulad ng pagdaragdag, pagbabawas, pagpaparami, at paghahati.

Hinihikayat namin ang iyong anak na lumahok sa aming pag-aaral na may pahintulot ng mga magulang/tagapag-alaga. Sa isasagawang pag-aaral, may ibibigay na survey form para sa kanila na nagtatanong tungkol sa kung paano ang performance ng application batay sa kung paano nila ginagamit. Ang mga mananaliksik ay hindi magtatanong ng anumang kumpidensyal na impormasyon tungkol sa kanila. Ang lahat ng impormasyong nakalap sa survey ay poprotektahan at gagamitin para sa pag-aaral na ito lamang. Ang paglahok sa pag-aaral na ito ay ganap na boluntaryo at hindi nagbibigay ng anumang benepisyo. Ang pasasaliksik na ito ay gaganapin sa **(buwan)** Sept **(petsa)** 3rd **, 2024.**

Kaming mga mananaliksik ay igagalang ang desisyon ng magulang/tagapag-alaga kung nais nilang hindi makilahok ang isang bata sa pag-aaral na ito.

Would you want to participate the child to this study? (Nais mo bang isali ang bata sa pag-aaral na ito?)

Yes ☐
No ☐

Name of the child: SUSHMITA UR B. CUATAYAY

Name of the parent/guardian: JAHARA PRECIOUS BUMOIN

Signature of the parent/guardian: [signature]

Date: 9-10-24

Appendix I

Informed Consent Form (RDIC (WHO) Form

OUR LADY OF FATIMA UNIVERSITY
COLLEGE OF COMPUTER STUDIES

Informed Consent Form for Marites A. Torres(Beneficiary)

This informed consent form is for Tagalag Elementary School participating in the research titled "MATH-WONDERS: Augmented Reality Flashcards Using Image Recognition Algorithm for Enhanced Children's Learning".

Tayam, John Emmanuel E.
College of Computer Studies, Our Lady of Fatima University – Valenzuela City

This Informed Consent Form has two parts:

- **Information Sheet (to share information about the study with you)**
- **Certificate of Consent (for signatures if you choose to participate)**

You will be given a copy of the full Informed Consent Form

Part I: Information Sheet

Introduction

I am John Emmanuel E. Tayam, a student of Our Lady of Fatima University. We are conducting research regarding a technology that can be used to help grade two (2) pupil who finds difficulties of mathematics. By considering our Augmented Reality-Based system application, we want to reduce their difficulties and ignite their desire to learn in math. We are inviting the Principal of Tagalag Elementary School, Marites A. Torres to participate in this research. Before you decide, you can talk comfortably with any of the investigators regarding the research.

If you encounter words or phrases, you do not understand, please do not hesitate to ask the investigators to clarify and explain it, as well as to ask questions related to the research.

Purpose of the research

The purpose of our research is to help grade two (2) pupil to reduce their mathematical anxiety and improve their skills in mathematics by using our *"Math-Wonders AR app"*. The initiative aims to enables young minds to learn how to study fun and intriguing by engage them in Augmented-Reality (AR) based technology.

Type of Research Intervention

This study will require your participation in a ten (10) minutes of instructions on how to use the application and demonstration, and three (3) minute for answering the satisfactory survey.

Participant Selection

We, the researchers want to participate all Grade two (2) pupils of Tagalag Elementary School to be part of our research. The goal of this project is to provide insightful information on the use of Augmented Reality (AR) technology to support grade two (2) pupils experiencing mathematical difficulties in their mathematical learning.

Voluntary Participation

Participation in this research is at your discretion and entirely voluntary. You hold the right to opt out of the study at any point, without any penalty or loss of benefits owed to you. Your choice to decline participation or withdraw from the study will not impact your relationships with your loved ones.

Procedures

1. As a participant in our research titled *"Math-Wonders: Augmented Reality Flashcards with Image Processing Algorithms and AI Bot for Enhanced Children's Learning"*, you will be participate to evaluate how our system is effective to help grade two (2) pupils. It will assess how Augmented Reality (AR) app works. Your participation will provide valuable insights into how our system will improve for future updates. We will keep your responses confidential and secure, and only us the researchers will be able to access them.

2. After testing our system, the participant will be requested to evaluate our system by giving a survey satisfactory questionnaire. We encourage the participant to provide honest feedback and review on our application.

Duration

The research will be conducted from February to December 2024. During this time, we will ask for permission taking thirty (30) minute of time interruption to conduct our research. We will creating a letter of permission sign by School Principal that will serve as letter to show to grade school teacher allowing us to interrupt his/her class.

Risk

We understand that there may be instances where personal or confidential information may inadvertently be shared, or certain topics may cause discomfort. Nevertheless, we strive to ensure that

this does not occur. Please keep in mind that you are not obligated to answer any questions that make you feel uneasy or are deemed too personal.

Benefits

Although the benefits may not be immediate for you personally, your participation will greatly improve the child's progress in mathematics. By allows us to create an app that can help a child familiarize themself the mathematics and reduce mathematical anxiety in an interactive way using an Augmented Technology Based Application. Ultimately, this will lead to a positive effect on a child's progress in mathematics. Thus, the Tagalag Elementary School will benefit from this.

Reimbursements

We would like to inform you that as part of our research, we will be covering the expenses required for the study. However, we do not intend to offer any incentives for participation. We appreciate your valuable time and contribution towards this research.

Confidentiality

As we will be conducting a study in the school campus, there will be an occurrence that will peak people's interest, prompting them to inquire about your participation. We will not share information about you with anybody outside of the research team given that this is a classified investigation and the research team will maintain the confidentiality of data with respect to both information about the participant and information that the participant shares. The information gathered from this study endeavor will be kept private. Any information about you will include a number instead of your name. Only the researchers will know what your number is, and we will keep it secure with a lock and key. It will not be shared or given to anyone.

Sharing the Results

We guarantee that the data you submit to us won't be shared with unrelated parties; no details about you will be attached. Before it is made public, the information we gather will be shared with you and your community. An overview of the findings will be given to each participant. Additionally, we will disseminate the findings after the sessions so that further interested parties can benefit from the study.

Right to Refuse or Withdraw

As a participant, you have the option to opt out of taking this research survey. Your involvement is optional, especially if it may have an impact on you personally. After completing the survey, you will be able to evaluate your responses. If you disagree with any of your remarks or

misread any instructions that resulted in wrong replies, you have the option to alter or eliminate those elements of your input.

Who to Contact?

If the participant has any question, you can ask us directly during the survey or if the questions occur outside the surveying period you can reach the researchers through the following contact information below.

John Emmanuel E. Tayam

Student/ Principal Investigator

Contact Number: 09156514733

Email: jetayam5566val@student.fatima.edu.ph

Part II: Certificate of Consent

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions I have been asked have been answered to my satisfaction. I consent voluntarily to be a participant in this study

Print Name of Participant MARITEV A. TORREV
Signature of Participant _____
Date 12 / 07 / 2024
Day/month/year

If illiterate [1]

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Print name of witness_____ **Thumbprint of participant**
Signature of witness_____
Date _____

Day/month/year

Statement by the researcher/person taking consent

I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the participant understands that the following will be done:

1. We will ensure the utmost confidentiality of the respondents' information, and the researcher is committed to protecting and securing the data provided.
2. Participants can relax knowing that their safety is protected in a secure research environment throughout the entire procedure.
3. The study is optional and participants are free to leave at any time without facing any consequences.

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

A copy of this ICF has been provided to the participant.

Print Name of Researcher/person taking the consent John Emmanuel Tayam
Signature of Researcher /person taking the consent _____
Date 12 / 07 / 2024
Day/month/year

[1] A literate witness must sign (if possible, this person should be selected by the participant and should have no connection to the research team). Participants who are illiterate should include their thumb print as well.

Appendix J

User Acceptance Form

User Acceptance Form

Thesis Project	Math-Wonders: Augmented Reality Flashcards Using Image Recognition Algorithm for Enhanced Children's Learning

Beneficiary: Grade 2 Students (Tagalag Elementary School)

Criteria	Yes/No	Comments
1. Is the project has been deployed in Grade 2 Students in Tagalag Elementary School?	Yes	
2. Is the flashcard detected properly during the user tested the app?	Yes	
3. Is the user tested and reviewed the project (application)?	Yes	
4. Is the modifications and additions meet mutually-agreed upon requirements?	Yes	
5. Is the project works as intended and without issues during normal use?	Yes	
6. Is the development of the application system feature is fully completed?	Yes	The development of this system will definitely aid our learners. Congratulations &

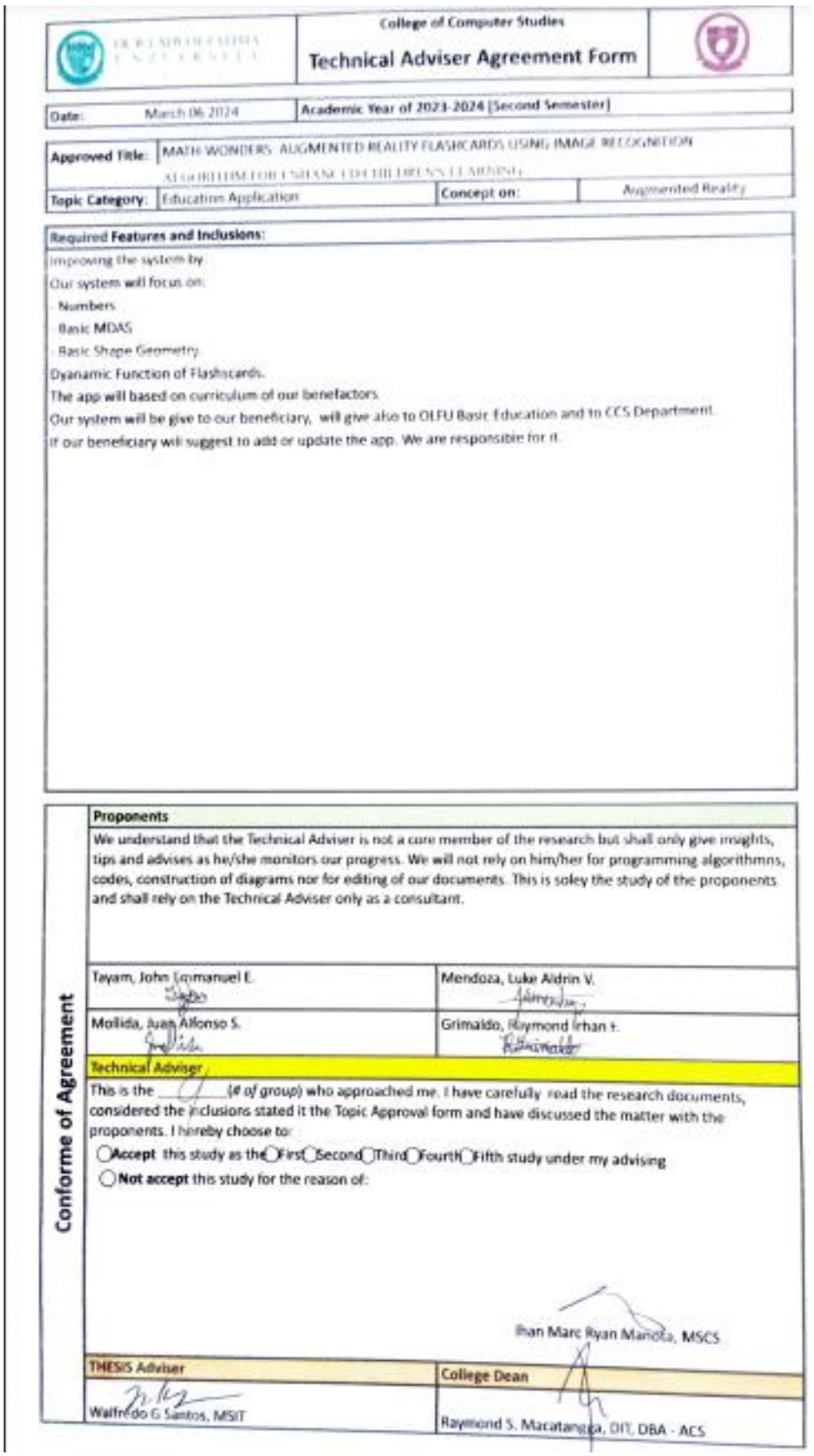
Date: December 05, 2024

Marrites A. Torres

Principal, Tagalag Elementary School (Beneficiary)

Appendix K

Technical Adviser Agreement Form



College of Computer Studies

Technical Adviser Agreement Form

Date: March 06 2024	**Academic Year of 2023-2024 [Second Semester]**

Approved Title: MATH WONDERS: AUGMENTED REALITY FLASHCARDS USING IMAGE RECOGNITION ALGORITHM FOR ENHANCED CHILDREN'S LEARNING

Topic Category:	Education Application	**Concept on:**	Augmented Reality

Required Features and Inclusions:

Improving the system by

Our system will focus on:

- Numbers
- Basic MDAS
- Basic Shape Geometry

Dyanamic Function of Flashcards.

The app will based on curriculum of our benefactors.

Our system will be give to our beneficiary, will give also to OLFU Basic Education and to CCS Department.

If our beneficiary will suggest to add or update the app. We are responsible for it.

Conforme of Agreement

Proponents

We understand that the Technical Adviser is not a core member of the research but shall only give insights, tips and advises as he/she monitors our progress. We will not rely on him/her for programming algorithmns, codes, construction of diagrams nor for editing of our documents. This is soley the study of the proponents and shall rely on the Technical Adviser only as a consultant.

Tayam, John Emmanuel E.	Mendoza, Luke Aldrin V.
Mollida, Juan Alfonso S.	Grimaldo, Raymond Irhan T.

Technical Adviser

This is the ____ (*# of group*) who approached me. I have carefully read the research documents, considered the inclusions stated it the Topic Approval form and have discussed the matter with the proponents. I hereby choose to:

◯ **Accept** this study as the ◯ First ◯ Second ◯ Third ◯ Fourth ◯ Fifth study under my advising

◯ **Not accept** this study for the reason of:

Ihan Marc Ryan Manoba, MSCS

THESIS Adviser	**College Dean**
Walfredo G Santos, MSIT	Raymond S. Macatangga, DIT, DBA - ACS

Appendix L

System Progress Report Form

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Valenzuela City
College of Computer Studies

SYSTEM PROGRESS REPORT FORM
First Semester, S.Y. 2024 – 2025

Proponents' Name:
(P1) Tayam, John Emmanuel E. :
(P2) Mendoza, Luke Aldrin:
(P3) Mollida, Juan Alfonso:
(P4) Grimaldo, Raymond Irhan:

Capstone / Thesis Title: MATH-WONDERS: Augmented Reality Flashcards Using Image Recognition Algorithm for Enhanced Children's Learning

EXPECTED COMPLETION DATE : 10/29/24

(To be Filled up by the Proponents)

Done in All Answers
Error Message for cleared, Factors and negative answers

System in Progress
None

Difficulties in Progress
None

Changes from Previous Plan, if any
None

(P1): Tayam, John Emmanuel E.

(P2): Mendoza, Luke Aldrin

(P3): Mollida, Juan Alfonso

(P4): Grimaldo, Raymond Irhan

(To be Filled up by the Research Adviser)

Comments and Suggestions

Ihan Marc Ryan Manota, MSCS
Technical Adviser Name

10/29/24
Date

Appendix M

Endorsement Letter

OUR LADY OF FATIMA UNIVERSITY
COLLEGE OF COMPUTER STUDIES

Nov 13, 2024

Our Lady of Fatima University Valenzuela Campus
College of Computer Studies

Subject: Endorsement Letter for CCS Public Presentation 2024

To the Panelist,

The following group completed chapter 1 to 5 and 100% of their system, in completing the requirements for (CSTH312) Thesis 2. We highly recommend them to present their project entitled "Math-Wonders: Augmented Reality Flashcards using Image Recognition Algorithm for Enhanced Children's Learning" in the CCS Public Presentation 2024. We'd like to express our support for this project and my conviction that this research will be worthwhile. The following proponents are:

Tayam, John Emmanuel E.
Mendoza, Luke Aldrin V.
Mollida, Juan Alfonso S.
Grimaldo, Raymond Irhan F.

We appreciate your consideration to this matter. Thank you very much!

Endorsed by:

Ihan Marc Ryan Manota
Technical Adviser

Appendix N

Ethical Review Clearance

OUR LADY OF FATIMA UNIVERSITY
IERC
INSTITUTIONAL ETHICS REVIEW COMMITTEE

R.I.S.E. Tower, Fatima Avenue
Marulas, Valenzuela City
283-9754 loc 1204
ierc@fatima.edu.ph

September 9, 2024

TAYAM, JOHN EMMANUEL
College of Computer Studies
Our Lady of Fatima University
Reference Number: 2024-IERC1-20845v2

Dear Mr./Ms. Tayam,

I am pleased to inform you that the research protocol for your research entitled **MATH-WONDERS: AUGMENTED REALITY FLASHCARDS USING IMAGE RECOGNITION ALGORITHM FOR ENHANCED CHILDREN'S LEARNING** has been **APPROVED** by the Institutional Ethics Review Committee of the Our Lady of Fatima University. This means that your research protocol has passed the ethical standards imposed by the Philippine Health Research Ethics Board (PHREB).

The following are the standard guidelines for you to follow:

1. This approval will take effect for a period of twelve (12) months. At the end of this period, if the project has not been completed, you are required to accomplish an Application for Continuing Review Form, one month before the period ends, in order to renew the approval for another term. Approval effectivity period: September 9, 2024 to September 9, 2025.
2. Once the study has been completed, or if for any instance terminated at an earlier time, you are required to submit a Study Completion/Termination Form, so that the committee can officially close the protocol.
3. The approved research protocol much be followed at all times in order to protect the integrity of your human subjects. Changes in the protocol and materials utilized in the study necessitate you to submit a Protocol Amendment Form, to be approved by the committee once received.
4. In such occurrence when the protocol was not followed, you are required to accomplish a Protocol Deviation/Violation Form within seven (7) working days after the occurrence in order to document the event.
5. For studies that require longer periods of investigation, a Progress Report Form must be accomplished every semester.
6. Failure to comply with the standard guidelines can lead to disapproval, or termination of the research protocol.

I, together with the ethics committee, am very much excited for the completion of your investigation.

Sincerely,

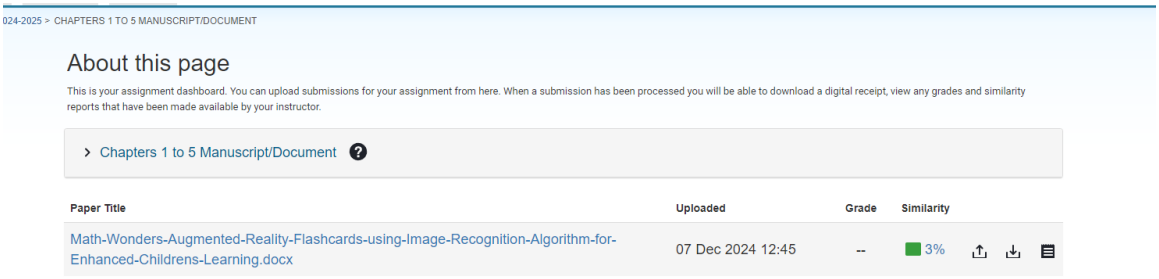
Jenica Ana A. Rivero, MAN., RN, PGDipHS
Chair, Institutional Ethics Review Committee
Our Lady of Fatima University

Form 2.3

Appendix O

Turnitin Result


Match Overview
3%
1 earist.edu.ph Internet Source 1%
2 www.stepacademic.net Internet Source <1%
3 www.globalscientificjo... Internet Source <1%
4 ijmra.in Internet Source <1%
5 www.coursehero.com Internet Source <1%
6 www.testmagzine.biz Internet Source <1%
7 www.theseus.fi Internet Source <1%
8 Sara Mouali, Mohamm... Publication <1%
9 ijssst.info Internet Source <1%
10 Sai Kiran Oruganti, Dim... Publication <1%


024-2025 > CHAPTERS 1 TO 5 MANUSCRIPT/DOCUMENT
About this page
This is your assignment dashboard. You can upload submissions for your assignment from here. When a submission has been processed you will be able to download a digital receipt, view any grades and similarity reports that have been made available by your instructor.
Chapters 1 to 5 Manuscript/Document
Paper Title
Uploaded
Grade
Similarity
Math-Wonders-Augmented-Reality-Flashcards-using-Image-Recognition-Algorithm-for-Enhanced-Childrens-Learning.docx
07 Dec 2024 12:45
--
3%

Appendix P

Respondent's Profile

Respondents No.	Year Level	Types of Respondents
Respondent 1	Grade 2	End-User
Respondent 2	Grade 2	End-User
Respondent 3	Grade 2	End-User
Respondent 4	Grade 2	End-User
Respondent 5	Grade 2	End-User
Respondent 6	Grade 2	End-User
Respondent 7	Grade 2	End-User
Respondent 8	Grade 2	End-User
Respondent 9	Grade 2	End-User
Respondent 10	Grade 2	End-User
Respondent 11	Grade 2	End-User
Respondent 12	Grade 2	End-User
Respondent 13	Grade 2	End-User
Respondent 14	Grade 2	End-User
Respondent 15	Grade 2	End-User
Respondent 16	Grade 2	End-User
Respondent 17	Grade 2	End-User
Respondent 18	Grade 2	End-User
Respondent 19	Grade 2	End-User
Respondent 20	Grade 2	End-User
Respondent 21	Grade 2	End-User
Respondent 22	Grade 2	End-User
Respondent 23	Grade 2	End-User
Respondent 24	Grade 2	End-User
Respondent 25	Grade 2	End-User
Respondent 26	Grade 2	End-User
Respondent 27	Grade 2	End-User
Respondent 28	Grade 2	End-User
Respondent 29	Grade 2	End-User
Respondent 30	Grade 2	End-User
Respondent 31	Grade 2	End-User
Respondent 32	Grade 2	End-User

No.	Name	Job
Respondent 1	Joy C. Dela Rosa	Math Coordinator/Teacher
Respondent 2	Novelyn G. Faner	Math Teacher
Respondent 3	Maria Ezara T. Dionivio	Math Teacher

No.	Name	Job
IT Expert 1	Cindy Valenzona	Software Engineer
IT Expert 2	Michael John Generoso	Software Engineer
IT Expert 3	Joylyn G. Macapugay	Software Engineer
IT Expert 4	Daniel Dave Mendoza	Software Engineer
IT Expert 5	Gerome M. Roque	IT Supervisor

Appendix Q

User Manual

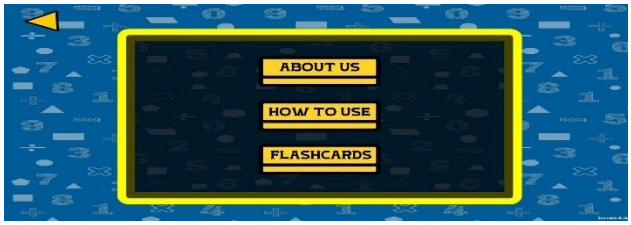
How to use Math-Wonders User Manual:

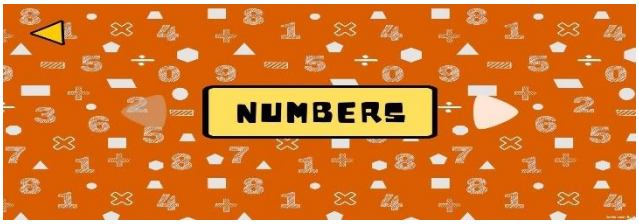
1. Start the Application.
2. Choose any AR mathematical operations
3. Study and understand the content in Learn Option
4. Read and understand the instruction before taking Quiz option
5. Answer the question within the given time
6. Read and understand the instruction before using AR option
7. Launch Flashcards applicable to the chosen mathematics lesson
8. Point the device's camera at the flashcard
9. Once a flashcard is detected, a 3D model will appear
10. Ensure an active internet connection to download the flashcards

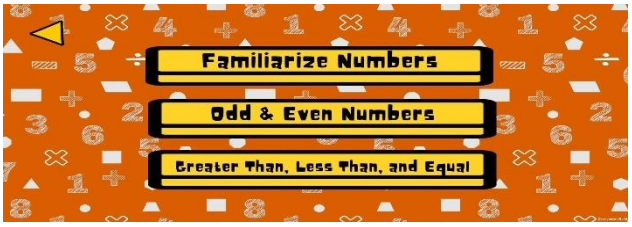
Appendix R

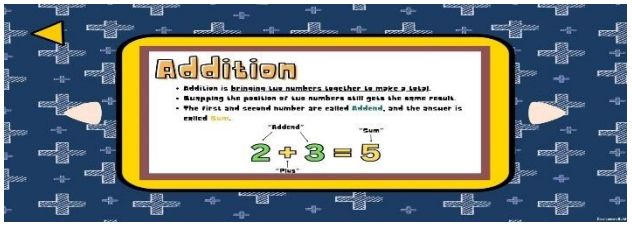
Screenshot of the System

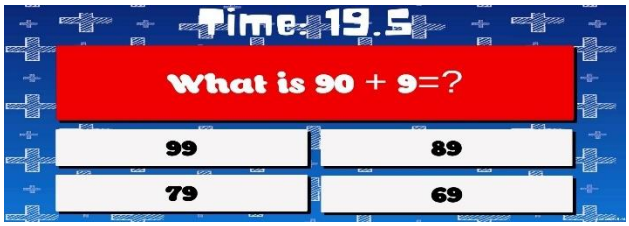

START
QUIT
MATH WONDERS


ABOUT US
HOW TO USE
FLASHCARDS


NUMBERS


Familiarize Numbers
Odd & Even Numbers
Greater Than, Less Than, and Equal


Addition
2 + 3 = 5


Time: 19.5
What is 90 + 9=?
99
89
79
69

Appendix S

Beneficiary Consultation Letters

Ms. Novelyn Faner
Mathematics Teacher
Tagalag Elementary School

Dear Ms. Faner!
Good day!
We'd like to give a summary of the important contents discussed at our March 19 meeting regarding the proposed system enhancements.

1. **Numbers**: We opted to keep the range exclusively between 0 and 99. Furthermore, it would be nice if each displayed number had accompanying text above it that clearly indicated which number it represented. Adding a voiceover for each number would improve the experience significantly. Furthermore, we should eliminate all animal components from the display after a number appears, focusing exclusively on the digits.
2. **Addition and Subtraction**: We will only consider single-digit numbers, single-to-double-digit numbers, and selected double-digit numbers. We'll limit double-digit integers to the following values: 20, 30, 40, 50, 60, 70, 80, and 90. Lastly, excluding any negative responses or add a comment noting that they are not included in the calculations.
3. **Multiplication and Division**: For this section, we shall carefully limit the range to digits 0 through 10. Disregarding any responses that surpass 99, as well as those that contain fractions or decimals.
4. **Basic Shapes**: Include only the shapes circle, square, triangle, rectangle, oval, trapezoid, rhombus, pentagon, octagon, and hexagon. Furthermore, make sure that each form is accompanied by text that describes the number of sides it has or a real-world object that looks like it.
5. **Learn**: It would be useful if we could begin each topic with a brief explanation so that users have a clear understanding of the issue. Additionally, adding a short example might help users understand the concept. Presenting the information in this manner should make the content look more like an organized learning module, allowing users to engage with the subject more effectively
6. **Quiz:** We limit the quiz to ten questions. To guarantee that user can easily engage with the material, it is best to establish a timer for each question, allowing 20 seconds per question. Ensure that all questions are relevant to the course and clear for the users. This format will keep the quiz focused while providing a timely and entertaining experience.

We want to express our heartfelt gratitude for meeting with us and sharing your unique views during the session. Your advice is very welcomed and will be useful in determining our next moves. Thank you again for your time and support.

Sincerely yours,

JOHN EMMANUEL E. TAYAM
Principal Investigator

JUAN ALFONSO S. MOLLIDA
Researcher

LUKE ALDRIN V. MENDOZA
Researcher

RAYMOND IRHAN F. GRIMALDO
Researcher

Conforme:

Ms. Novelyn Faner
Mathematics Teacher

Ms. Novelyn Faner
Mathematics Teacher
Tagalag Elementary School

Dear Ms. Faner!
Good day!
We'd like to give a summary of the important contents discussed at our September 20 meeting regarding the proposed system enhancements.

1. **Odd & Even Numbers**: We wanted to examine the structure we mentioned for the number content because we believe it should be in the same pattern as the prior section. For this section, it would be ideal to have a voiceover for each number, allowing users to hear it as it is presented. Also, we make sure that the system clearly states whether each number is odd or even. This feature will help users better understand the notion, like we did with the other topics.
2. **Greater than, Less than & Equal, Time, and Money**: We wanted to point out that there is no need for Augmented Reality content in this part. Instead, it would be better to include both a "Quiz" and a "Learn" part. The "Learn" part will assist the user understand the lesson, and the "Quiz" will allow them to put what they've learned into practice. This method ensures that the content is both instructional and engaging, allowing the user to participate with the material in a way that increases comprehension and retention.
3. **Short video Introduction**: The content should only contain numbers, MDAS (Mathematical Operations), and fundamental shapes, each followed by a brief video presentation. However, there is no need to put videos in the time and money areas. This technique keeps the content focused and guarantees that the videos improve understanding of fundamental ideas while simplifying the material for a more effective learning experience.
4. **Downloaded Flashcards.** It would be useful to add guidelines for using the best printing materials, such as high-quality paper. This ensures that the cards are long-lasting and easy to replace if they become misplaced or filthy. In addition, we propose giving a box to store the flashcards. This will keep them organized and prevent them from being destroyed or misplaced, allowing users to conveniently retrieve them when necessary.

We want to express our heartfelt gratitude for meeting with us and sharing your unique views during the session. Your advice is very welcomed and will be useful in determining our next moves. Thank you again for your time and support.

Sincerely yours,

JOHN EMMANUEL E. TAYAM
Principal Investigator

JUAN ALFONSO S. MOLLIDA
Researcher

LUKE ALDRIN V. MENDOZA
Researcher

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Conforme:

Ms. Novelyn Faner
Mathematics Teacher

CURRICULUM VITAE

John Emmanuel E. Tayam

Principal Investigator

Contact

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Technical Skills

- Languages: C++, Java, Python, HTML, CSS, JavaScript,
- Application: MS Office, Canva, Unity 3D, Visual Studio Code, Blender
- Computer Hardware: PC Building, PC Troubleshooting, Technical Support

Education

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(Batch 2020)
CHILDREN OF MARY IMMACULATE COLLEGE
General Academic Strand
Senior High School

(Batch 2017)
VALENZUELA NATIONAL HIGH SCHOOL
Junior High School
Public School

(Batch 2013)
MARULAS CENTRAL SCHOOL
Grade School
Public School

Achievements

- 2nd Place: Research Exhibit
- Dean's Lister A.Y 2022-2023
- PCAP - Programming Essentials in Python (2022)

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Senior High School

(2012 - 2015)
MARY-CHILD ACADEMY
Grade School
Private School

(2010 - 2012)
SAINT MARY MONTESSORI
Grade School
Private School

Achievements

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Grade School
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Achievements

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- Application: MS Office
- Computer Hardware: PC Troubleshooting

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Science, Technology, Mathematics and Engineering
Senior High School

(2015 - 2019)
SAN ISIDRO SAN ROQUE ACADEMY
Junior High School
Private School

(2010 - 2015)
JOHN PAUL BENEDICT SCHOOL
Grade School
Private School

Achievements

- 2nd Place: Research Exhibit
- Dean's Lister A.Y 2022-2023
- PCAP - Programming Essentials in Python (2022)