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Educational AR Mystery Puzzle Game for Children

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***Abstract*—AR (AR) has been on the rise in which it has been implemented in many fields. Children these days have low attention span when they have no electronic devices on them. To deal with this issue, the aim of this research is to design an educational AR mystery puzzle for children aged 4 to 6. Therefore, the objective of this research is to analyse the user engagement, problem solving skills and the learning outcome with the AR mystery puzzle with an interesting storyline and lastly, to evaluate the AR mystery puzzle design where it focuses on the usability. There are 2 levels provided in the prototype, for level 1 the users were required to choose one marker out of the two markers provided, and for level 2 the users were required to choose two markers out of the three markers provided to go through with the story. Moreover, players can inspect the items before making the final decision and the leader board score is based on the time taken to finish the game. Waterfall methodology is used for this research since the workflow of the proposed game is an initial prototype to better understand its potential based on the objectives and scopes covered with a clear requirement. For the evaluation, usability tests are done as well as the functionality testing. The results showed that this proposed game design can inspire children for them to be exposed to an AR mystery puzzle game and be educated with essential life skills.**

***Keywords*—Educational AR, Mystery Puzzle Game, Children**

I. INTRODUCTION

In today's modern technological era, it is increasingly easy for children to find themselves wasting some of their most important developmental years on games designed to merely keep them engaged with quick and cheap thrills. Often, games targeted towards children have little to no depth or challenge, making their educational value close to nil. Due to this, it is important for us to understand how to utilize new technologies in a manner where they can be used to develop new and innovative ideas and execute them in a fun and educational way.

Augmented reality, also known as AR games have the potential to change how games are played and used today and help educate gamers as they play [1]. There is plethora of potentials that can be implemented into AR games to enhance student's engagement such as gamifications whereby adding elements such as challenges and rewards upon completion can motivate players to keep on playing. Children tend to be bored if they only use reading material, hence providing then AR will help in aiding children's experience with learning. AR instructing material may be a great alternative to ordinary picture books and physical interactions [2].

A normal puzzle game can be distinguished easily from a mystery puzzle game. Normal puzzles are sometimes straightforward with their objectives. Such an example can be seen in sudoku where a 9x9 square must be filled with numbers from 1 to 9 in which there are no repeated numbers horizontally and vertically. On the contrary to mystery puzzles, the objectives are to gather clues and piece together the information to solve a problem. Such objectives can be seen in one of the CSI: Hidden Crimes games. Other than that, mystery puzzle games usually have a storyline that provides more context and motivation for the players and this cannot be seen with normal puzzles. Timeframe taken to complete a normal puzzle can be solved at any pace because such games depend on the person to solve the problem, but as for mystery puzzles, since it follows a storyline, once the player has reached the ending, that is the end for the game. Children nowadays have low attention span especially when they are not occupied with electronic devices [3]. Not only that, but normal puzzles are also limited in educational value in which they lack learning objectives and fail to consider the children's specific learning needs and interests [4]. Moreover, it also has limited problem-solving opportunities whereby it will hinder the children's critical thinking skills and resulting in overlooking chances at development and growth [5].

II. LITERATURE REVIEW

A. AR (AR)

AR can be defined as a direct or indirect real-time view of a physical real-world setting that was enhanced or augmented by the addition of virtual-generated data to it [6]. AR is also a combination of interactive and 3D captured, combining actual and virtual items. In 1994, Paul Milgram and Fumio Kishino has come up with Reality-Virtuality Continuum in which AR (AR) and Augmented Virtuality (AV) exists on a continuum between the actual world and virtual world, with AR being closer to the actual world and AV being closer to an entirely digital setting [7]. Fig. 1 below shows the Milgram's Reality – Virtuality Continuum.

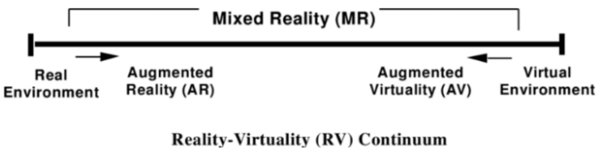

Fig. 1. Milgram's Reality – Virtuality Continuum

B. Type of Tracking Techniques

Tracking techniques can be divided into 2 parts which are sensor-based tracking and vision-based tracking. Each of them has their advantages and disadvantages. The tracking technique used for this research is vision-based tracking, which is known as marker-based tracking. The precision for marker-based tracking is more accurate but markerless tracking is more of a robust tracking. The expenses for marker-based tracking are reasonable while markerless tracking is more expensive. The advantages of the marker-based tracking are that the information of the marker is stored in the database while markerless tracking reduce the quantity of data required to extract as it allows natural features for tracking instead of artificial. The cons for markerless tracking are that it involves a lot of computational difficulties. The charaxcteristics of different tracking techniques are showed in Table I.

C. Educational Technology using AR

AR has potential to be implemented in educational settings. The potency of this technology over the years has led to an increase in the number of studies on AR [8]. AR also offers a practical method for visualizing models that are needed to be represented [9].

With AR implementation in the educational settings, there are plenty of advantages that can help students improve their learning. For example, AR offers a practical method for visualizing models that need to be represented. Due to AR's detailed visualization and object animation capabilities, it can reduce misunderstandings that result from student's inability to visualize ideas like chemical bonds [10]. Another benefit of AR is that it enables macro and micro visualization of things and ideas that are invisible to unaided eye. AR presents object and concepts in various ways and from various viewing angles, which aids students in understanding the subjects [11].

TABLE I. CHARACTERISTICS OF DIFFERENT TRACKING TECHNIQUES

Tracking Techniques		Precision	Sensitivity	Expenses	Advantages	Disadvantages
Sensor-based tracking	Optical tracking	Accurate	Sensitive to optical noise	Expensive	Precise and robust when implemented in a controlled environment	The sensitivity of sensors towards noise and complex computation decreases the execution speed
	Magnetic tracking	Less accurate	Sensitive to nearby electronic devices	Expensive		Less accurate compared to optical tracking. Noise sensitive Sensors lead to a lack of accuracy with distance
	Acoustic tracking	Less accurate	Sensitive to temperature or humidity in the environment	Expensive		Slower execution
	Inertial tracking	Accurate	Sensitive to a small shift in the axis of rotation or the position		No external reference needed	Problems may arise in this system even if there is a small shift in the axis of rotation or the position
Vision-based tracking	Marker based tracking	Accurate		Reasonable cost	The marker information related to the position and identity attributes in the database	
	Markerless tracking	Robust tracking		Expensive	Reduces the quantity of data that is required to extract. Allows natural features for tracking instead of artificial	A lot of computational difficulties are involves

D. Puzzle Game

Puzzle games can be defined as more of a rule-based system. Puzzle games are more towards finding a solution to solve the problem instead of beating an opponent [12]. A puzzle is a task where player can have fun while trying to find the right answer or in another words, a question that ask the player to solve that needs the conclusion of based on the winner's idea, without relying on chance or the actions of others [13]. Hence, why most of the puzzle games are single player instead of multiplayer.

E. Puzzle Game Player Strategies

Puzzle games usually require the player to come up with a reasonable conclusion and think critically as the objective of the game is to complete the game within the game's rules [14]. This might take time for the player to solve the puzzle. To understand what a player's strategy is during the game, there are usually two approaches. The first approach is playtesting or tracking the gameplay logs when the players are playing the game. The second approach is using game telemetry and game analytics [15]. This is a set of techniques designed to gather and analyse play traces. This allows game designers to understand what is going on in the player's mind throughout playing the game. By understanding the player, game designers can come up with more challenging or more suitable game ideas to implement into the game.

F. Game-Based Learning

Games and learning or a game-based learning is to achieve a balance between theoretical material and engaging learning experiences assisted by games. Students can engage in immersive learning settings where they can study difficult topics and accomplish learning objectives through game-based learning. The creation of engaging experiences that allow students to repeat cycles inside the game setting without boredom should be prioritized in the design of educational games. Furthermore, a well-designed educational game should generate desired behaviours in students throughout repeating situations by encouraging positive emotional and cognitive responses to the game's interaction and feedback [16].

Game-based learning also comes with functions like the game mechanics, visual aesthetic design, narrative design, and musical score. Game mechanics comes with the activity sets by the developer that can be done repeatedly by the learner throughout the game whereby the activities have a learning focus on it. Visual aesthetic design in the visual aspects include the game's look, including its characters, as well as the portrayal of critical information. The visual design impacts the visualisation of game mechanics, signals, and feedback, which serves both cognitive and aesthetic purposes. The narrative of a game refers to storyline, which is told through cutscenes, in-game activities, conversations, and voiceovers. Narratives are important in giving context for learning by linking game aspects such as characters, activities, events, and rewards. Furthermore, narratives add to the game's motivating component by increasing stickiness, or the desire to return and keep playing. Lastly the musical score is a soundtrack that is made up of background noises that serve many functions. It draws the player's attention to crucial events or moments, alert them to possible risk or opportunities, elicits positive or negative emotions, and acknowledges the success or failure of specified activities. Music in games is important for improving the entire gameplay experience and providing a more immersive and engaging atmosphere for the user [17].

Recent studies emphasize the role of gamification in maintaining intrinsic motivation. For instance, systematic reviews indicate that game-based learning significantly improves engagement compared to traditional instruction [18]. Furthermore, newer frameworks for "serious games" highlight the importance of immediate feedback loops and adaptive difficulty in fostering a state of flow, which is critical for learning retention in young children [19].

G. Educational Game Design Strategies for Children

For children at the age of 3 to 5, educational games tend to prioritize kindergarten readiness skills such as reading, math, thinking and reasoning, perceptual, fine motor, daily living, social, creativity and self-expression and understanding of concepts. Strategies that can be implemented into the game are demonstrations, stories, role models, providing choices, interactive questioning, and challenges. Demonstration can be done at the early stage of the game to show the children how the game works. As for stories, a storyline may capture a child's attention by offering thought-provoking concerns or difficulties to solve, while also keeping their interest as they anxiously await the story's ending. Characters that the children can relate to can demonstrate behavior or enact a skill and show effective ways to relate to others, modelling what the child can do in their life. To make the game more engaging, by providing choices to the children, they can progress towards reaching the goal and the satisfaction of completing the assignment might be simply pleasant. Characters in the tale can immediately engage the youngster by asking exciting questions, motivating their urge to think critically and find more best solutions and explore more. In addition to that, children are strongly motivated by mysteries, problem-solving exercises, simulations, and other goal-oriented activities. These activities develop a feeling of purpose and drive in youngsters, motivating them to persevere in their educational pursuits until they have mastered the needed skills or information [18].

Recent literature on child-centered design advocates for "scaffolding"—providing temporary support to help children achieve tasks they could not do alone. Researchers note that AR is particularly effective for scaffolding because it overlays cues directly onto the physical world [21]. Additionally, interactive storytelling has emerged as a powerful tool for this age group [22].

H. Novelty of the Proposed Prototype

While several AR applications exist for education (discussed below), there is a gap in tools that combine mystery-solving narratives with logic-based physical interaction for early childhood. Most existing applications focus on observation (e.g., viewing anatomy or animals). This project introduces a novel approach by requiring logical deduction (choosing the right tool for a problem) embedded within a narrative arc, moving beyond passive observation to active problem-solving using physical markers.

I. Similar Works

One of the previous applications that implement AR for educational purposes is Curiscope's Virtuali-Tee, where it allows people to learn more about the human body on a human body [23]. First, the application must be downloaded on the phone for the learning experience. This allows users to explore the anatomy in full 3D animation in which you can move around and look at the body. Moreover, it allows you to teleport inside the body for further exploration. The target age group for this Virtuali-Tee is children aged 4 and above. The advantage of this Virtuali-Tee is that when it is worn by the user and with the application's camera pointing to the shirt, users can see the human anatomy. With this, the user can learn anatomy and see where the parts of human bodies are and what is inside the body. The con of this application is that it only displays the AR, and the user cannot interact with the human body parts.

Another example of previous work is PhysicsPlayground. This application is developed to help students understand the concept of mechanics and support their studying. The 3-dimensional virtual environment allows students and teachers to create physical experiments which can be simulated in real-time [24]. This allows experiments that are hard to do in real life to be more convenient. The target for this application is students aged 15-17 who are learning physics, but it can also be used by university students. This application allows the users to interact with items such as by using the PIP, or known as the Personal Interaction Panel, and input devices like a pen. As for the cons, it is only available on desktop but not on mobile devices.

One of the examples of AR implemented work is Animal Safari AR. This application helps kids to understand and learn more about animals. It places a virtual realistic animal in front of anywhere where the camera is facing. The application also shows a description of the animal's information for a better understanding and the sound of the animal. Animal Safari AR is targeted towards people from the age of 4 and above [25]. This application provides users with an interactive and informative environment for learning about various animals. Users may learn about diverse species, their habitats, behaviors, and distinctive qualities by using AR features and educational material. The pro of this application is that users can interact with the AR object as the controls for it are touchscreen. The con of this application is the users cannot really do anything more because it is only to display the animals and learn about the animals.

III. METHOD

In this section, the methodology choice that is chosen is the waterfall model as it is more convenient to apply to this research (refer Fig. 2).

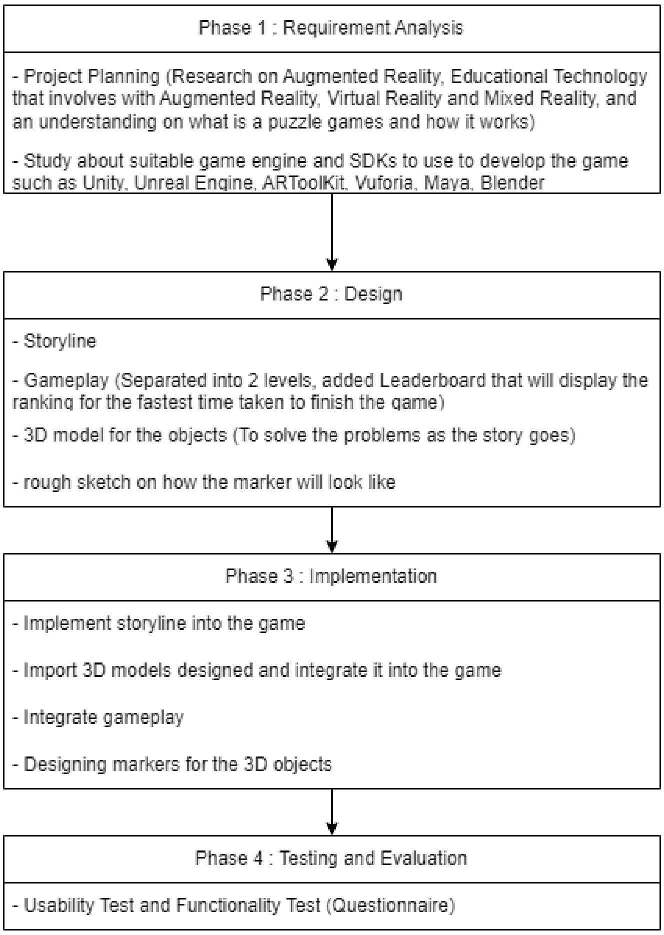

Fig. 2. Research Methodology

There are 4 main phases throughout this phase which are analysis, design, implementation, and lastly, testing and evaluation. The reason for this choice of methodology is because it is easier to implement, and when using this model, the requirements of the system can be defined as a whole, and right at the earlier stage of the research [26]. By using this model, the proposed prototype can run smoothly without running into issues.

A. Phase 1: Requirement Analysis

During this phase, research regarding AR is done. This is to have a deeper understanding of what AR is. Next is educational technology whereby it involves all Extended Reality (XR). This is to see the difference between AR, virtual reality, and mixed reality, especially in education. After that, a study regarding puzzle games is done to have a better understanding of what it is and how it works. Moreover, the existing applications on educational in AR are also being investigated as it is required as preparation for this proposed prototype. The user interfaces created need to be designed to maximize player's comfort and minimize player's fatigue during their gameplay sessions [27]. Other than that, it is a must to make proper adjustments to the game content, time limit, level of difficulty, and rules in consideration of factors such as the player's cognitive level, game level, and psychological characteristics [28]. Implementations for the prototype are mostly using mobile devices, where players can interact with AR objects [29]. The reasons for this are to compare the existing applications and the proposed prototype of where the differences are, and which can be improved. All the research done throughout this phase is used as references for the next stage.

B. Phase 2: Design

For phase 2, the storyline is developed to allow the players to follow the story throughout the game. The story comes in short and easier terms for the children to understand the game. It features a fox character named Finn, bringing the player along on an adventure into the woods where they find a map and Finn encourages the player to join him in the adventure.

As for the gameplay, the game consists of 2 levels. Level 1 consists of 5 questions in which the players must pick one of two markers to answer the problem. Meanwhile, Level 2 features three questions in which the player must identify the markers that will interact with one another and select the correct response to solve the problem. Players are allowed to inspect the item and hints will be given throughout inspecting the item.

Before proceeding to Level 2, the player is given the option of either going to Level 2 or saving and existing the main menu. A timer will be set at the beginning of the game and will continue to count until either the player reaches the end of Level 1 and saves the game, or the player reaches Level 2 and saves the game. Once the player has completed the game, their timer will appear on the leaderboard based on the shortest time taken to complete the game. Save options at the end of Level 1 and Level 2 serve as a checkpoint for the player to save their progress.

3D Models are mostly found in Sketchfab and edited in Blender to make them seem better and meet the tips provided to the player while completing the problem. The markers are created in two distinct colors: Level 1 has a green background and Level 2 has a brown background. This is to ensure that the players can distinguish between the two levels.

C. Phase 3: Implementation

The proposed prototype is built with Unity Engine where the normal scenes with the storyline are in 2D, while the AR camera will detect the markers in a 3D scene, and each question is separated into different scenes. The questions comprise a correct and incorrect scenario, and if the player gets the proper answer, they will be moved to the next question scene. However, before beginning a new question, it will display a few animations that show the player how the equipment is utilized to answer the problem. Before moving on to the next scene, the game will provide a map of where the player is and where they will go for the following question. The player will be able to verify their current location on the map by clicking a button. In a scene with the storyline, a text chat bubble will appear from a character in the game attempting to engage with the players. When the players are given questions, it will display two playable cards at Level 1 to guarantee that the users know which card to use for each question. Then it will show three cards that can be used in the questions for Level 2, two of which will interact with each other. When a player places an image target in the AR camera and scene, a 3D model appears, complete with sound and an inspection and pick button. Players can explore the 3D item, look for hints in the text, and choose it as an answer. When an incorrect response is picked, a failed sound is played, and when a correct answer is selected, a correct sound is played, indicating to the player that the answer is correct followed by an animation and the next question. The AR (AR) implementation of Vuforia SDK into the proposed prototype is critical since it aids with AR marker tracking. The markers produced are translated into image targets, allowing the 3D model to be shown as AR in a real-world setting. This is accomplished by integrating the Vuforia database into each picture target to ensure proper tracking. For this proposed prototype, the Vuforia database has a total of 19 markers including 10 for Level 1 and 9 for Level 2.

Integration for the database using Firebase is particularly crucial since it must keep three items, the email and password for authentication reasons, the current level of play, the player's username, and the amount of time spent in the game. To play the game, players must first create an account, which requires a username, email address, and password. At the same time, the database will assign the default values to the player at 0:00 and level 1. Logging into the game requires the player's email address and password. It will determine whether the player is on Level 1 or 2. If the player is on Level 1, they must begin the game at the beginning with the timer set to 00:00. Once the player has completed Level 1, they can choose whether to proceed to the next level or save and leave the game. This changes the saved level to Level 2 and saves time. If the player is at Level 2, it will start from where the player has last saved.

D. Phase 4: Testing and Evaluation

The study employed purposive sampling to recruit 22 children aged 4 to 6 from a local preschool environment. Prior to the study, ethical clearance was obtained, and informed consent forms were signed by the parents or guardians of all participants. The children were given a brief introduction to the device but were encouraged to play without step-by-step guidance to test intuitiveness (Black Box testing).

Testing and evaluation were the last steps in the procedure. The evaluation procedure was mainly focused on the player's performance and user experience with the target users, who are kids aged 4 to 6 years old. Usability testing and black box testing were the key evaluation methods. During usability testing, players are observed and analyzed while they engage with the game. To achieve the best user experience, factors such as navigation, intuitiveness, and general ease of use were assessed. The "smileyometer" test is utilized on the evaluation form, and students must color the faces on the form to communicate their sentiments and ratings. This allows children to easily express their satisfaction levels (Strongly Disagree to Strongly Agree). The questionnaire assessed five components: Learnability, Efficiency, Memorability, Errors, and Satisfaction [30].

E. System Flow

The flowchart of the system is shown in Fig. 3 below. When the user launches the game, they have three options: start the game, display the leaderboard, and quit the game. When the player selects start game, two more buttons appear: Register and Login. The player must register for an account by entering their username, email address, and password. After registering an account, the player must log into the game. If a saved file is found under the user's login credentials, the player will begin the game from Level 2. However, if no stored files exist, the player will be reset to Level 1. Once the player has entered their name, the game will begin. It will begin by showing the tale. Next, as the story progresses, difficulties will occur. The problem will then prompt the user to utilize markers to select a solution. When the marker is captured by the camera, the AR item appears. When the solution is incorrect, visitors will be prompted to provide a different response until they find the proper one. Once the proper answer is determined, the tale will continue until they encounter another challenge to solve. This game comes in two stages, with Level 1 requiring one of two objects to complete the task. This will continue until all five challenges are solved. After completing Level 1, the player can either save the file or go to Level 2. If the player wants to save the file, they can do so and return to the main menu. In Level 2, the player must enter two out of three objects to complete the puzzle. This will be repeated until all three issues are resolved. Once the user has completed all of the stages, the user's name and time required to complete the puzzle will be shown and may be seen on the leaderboard later. After that, it will return to the main menu, where the player may choose to play again, check the leaderboard, or exit the game. If a player clicks on the leaderboard, their only choice is to return to the main menu.

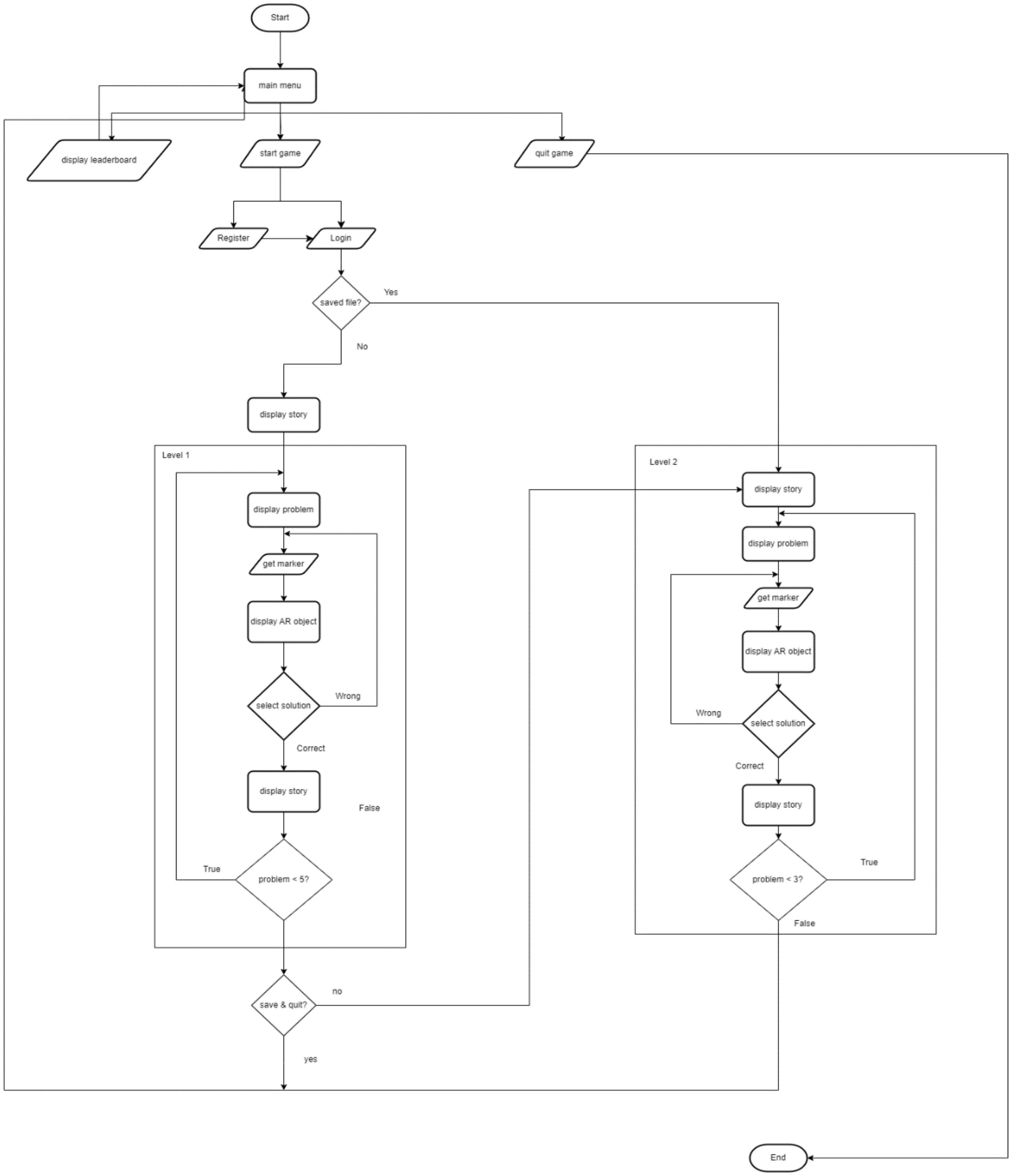

Fig. 3. System Flow

F. Game Design

This is the use case diagram for this game (showed in Fig. 4). The user can control the game, points the camera to the marker where the game will display the 3D object to the user and user can interact with the 3D object shown. After that, the user can select which of the 3D objects to be their answer. The user should be able to enter their name as well because it will be stored in the database for the leaderboard purpose. The game will be able to display the storyline and the AR object when the marker is shown. Other than that, the game must have 2 levels which is level 1 and level 2. It also should display the leaderboard scores with the name and the game will start its own timer when the game has started after the player login into the game.

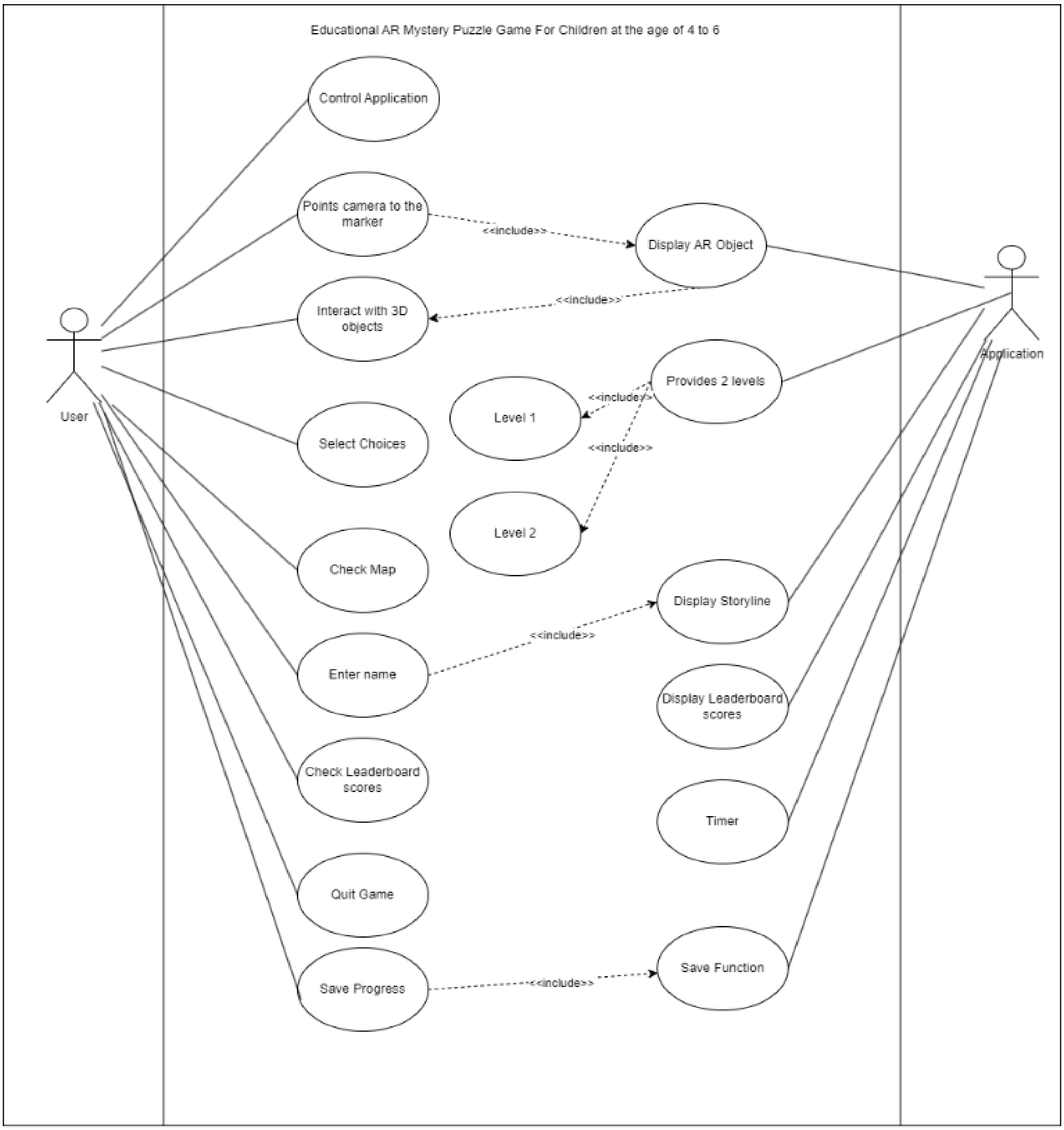

Fig. 4. System Flow

G. Database Design

Fig. 5 shows the database design for the game for this proposed prototype. There are two classes which are Leaderboard and Player where player will have playerID automati cally generated by Firebase which is the unique key for the Player class that will store the player's username, email, and password, level. In the leaderboard, it will take the playerID where it is a foreign key and display the player's username and the timer that will display the time taken to finish the game. Since there are 2 levels as well, levelID will store the levels which is level 1 and level 2. Under the class Level 1 and Level 2, it will store the player's username and timer. In the class Environment, the attributes will be inherited from the class

Level_1 and class Level_2, in which both the levels have levelID as their primary key, username, and timer.

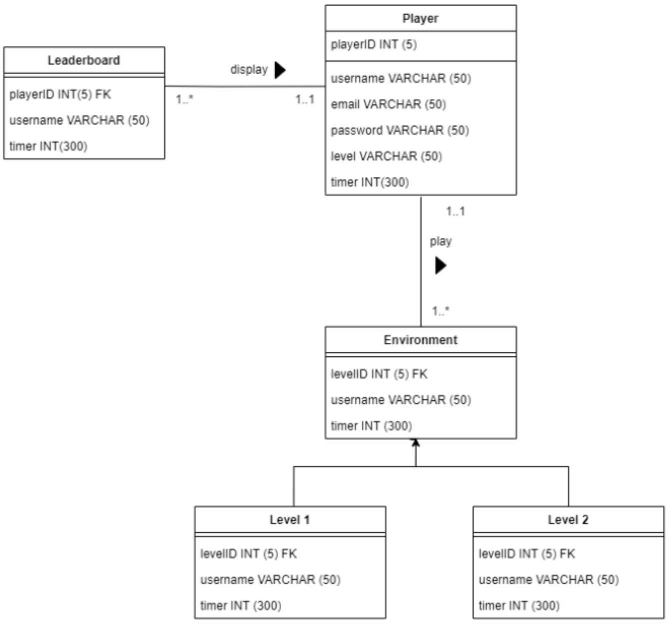

Fig. 5. Database Design

H. Interfaces

All figures from Fig. 6 are displaying the interfaces created for the game.

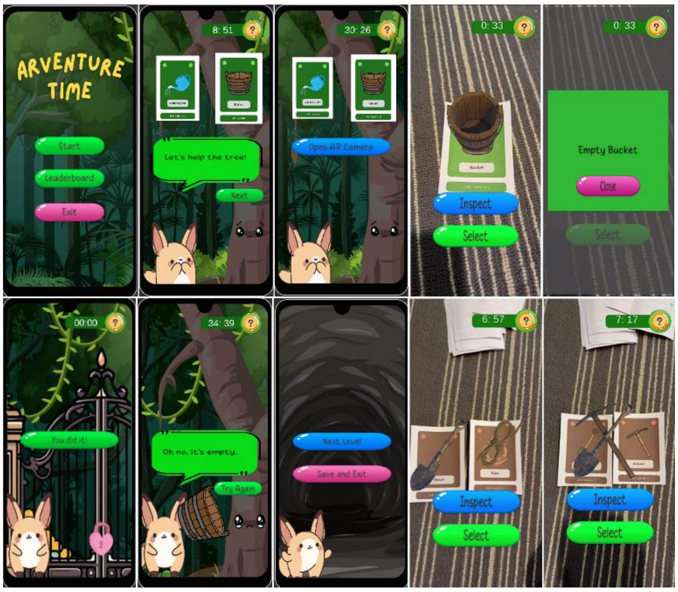

Fig. 6. A comprehensive visualization of the game's user experience (UX) and interface design. The figure maps the sequential flow: starting at the Main Menu; proceeding to the narrative-driven Storyline Interface; engaging with the core mechanic involving the Question Prompt and camera access for Augmented Reality (AR) marker scanning on the Capture Screen; utilizing the Inspection Screen for hints; receiving immediate feedback via Correct/Wrong Option Screens; and concluding a level with the Level Progression Screen. Additionally, the figure highlights the advanced gameplay in Level 2 by comparing the non-interactive and interactive Card Conditions that determine puzzle resolution

IV. RESULT AND DISCUSSIONS

The total number of respondents for the testing and evaluation stage was 22 respondents. These respondents are preschool children aged from 4 to 6 years.

A 2-page questionnaire was given to the respondent to gain the feedback on the proposed Game. The questionnaire was separated into 2 sections which is Section A that focused on the respondent's background, and Section B focused on the usability of the game.

Section A

Most of the respondents are at the age of 5 where female respondents are more than male respondents. While the majority of the respondents have no experience with AR, there are a few remaining respondents have prior experience to AR.

Section B

After the respondents completed section A, the respondents were given a certain amount of time play the game without any guidance, expect for the registering and login as it might be complicated for the children. The collected data was presented in linear scale so that the quantitative analysis and evaluation can be done.

In this form, the linear scale used for assessing the game experience of the player ranged from 1 being strong disagreement to 5 being strong agreement. The usability testing assessed the game experience based on 5 components taken from the core of the questionnaire, which the components were: Learnability, Efficiency, Memorability, Errors and Satisfaction [26].

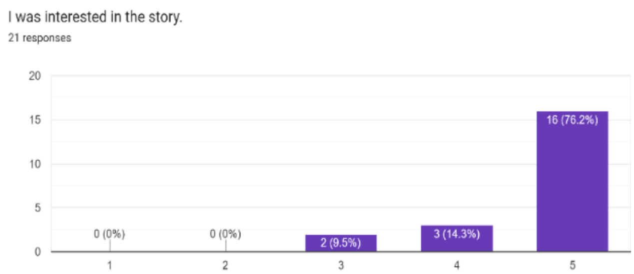

Fig. 7. The result of respondent interest in the story

Based on Fig. 7 above, 76.5% of the respondents strongly agreed that they were interested in the story, while 14.3% of the respondents agreed that they were interested in the story and 9.5% neither agreed nor disagreed that they were interested in the story.

Fig. 8 displays that most of the respondents (76.2%) strongly agreed that the game was aesthetically pleasing while a small portion of participants (9.5%) agreed that the game was aesthetically pleasing. A few participants (14.3%) were neutral about the game's aesthetics. It shows that most participants found the game to be aesthetically pleasing.

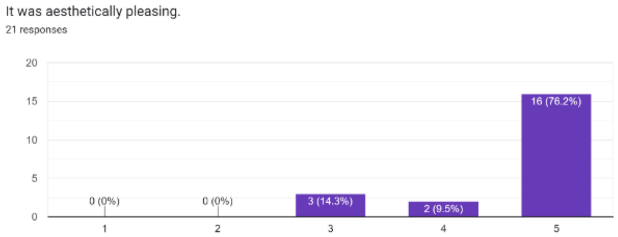

Fig. 8. The result of the aesthetic of the game

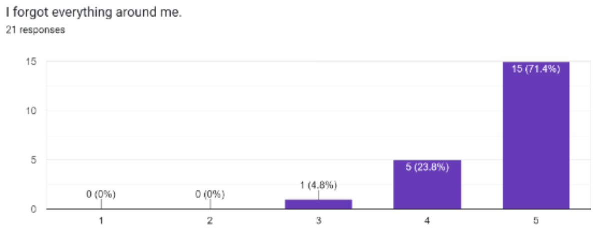

Fig. 9. The result of the immersiveness of the game

Fig. 9 shows the immersiveness of the game. Majority of the respondents (71.4%) strongly agreed that they forgot everything around them while playing the game. A smaller portion of the respondents (32.8) agreed with the statements while only one respondent (4.8%) was neutral. This shows that the game was engaging, can capture the player's full attention and was memorable for the respondents.

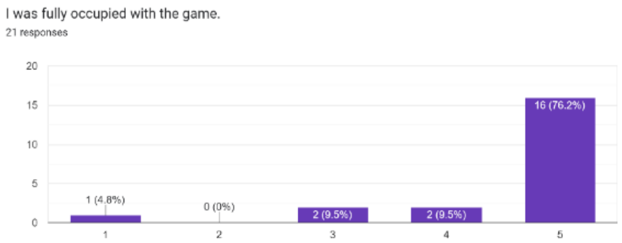

Fig. 10. The result for who are fully occupied with the game

Fig. 10 shows the result if the respondents are fully occupied with the game. The majority (76.2%) strongly agreed that they were fully occupied with the game, indicating high engagement. A smaller portion (9.5%) agreed, and another 9.5% were neutral. Only one respondent (4.8%) disagreed to the statement.

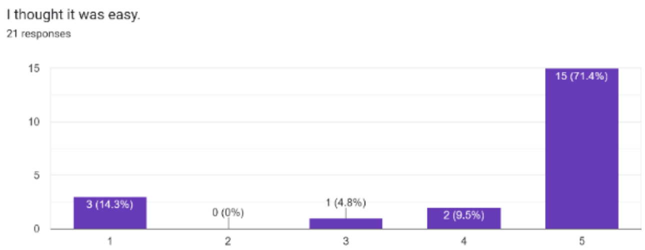

Fig. 11. The result of the respondents who thinks the game is easy

Fig. 11 displays the result of the respondent's thinks the game is easy. 3 respondents (14.3%) rated it a 1, indicating strong disagreement; 1 respondent (4.8%) rated it a 3, indicating a neutral stance; 2 respondents (9.5%) rated it a 4; and the majority, 15 respondents (71.4%), rated it a 5, indicating strong agreement. This shows that most participants found the task easy.

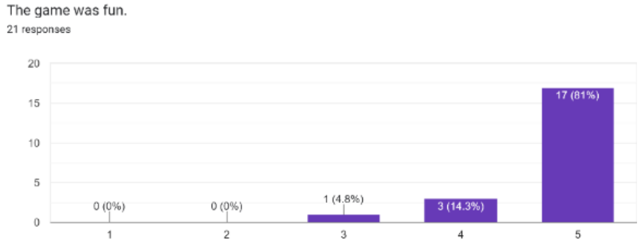

Fig. 12. The result of the game being fun

Fig. 12 discussed the results of the fun aspect of the game. Most of the respondents (81%) strongly agreed that the game was fun, while 3 respondents agreed that the game was fun and 1 respondent (4.8%) was being neutral about it.

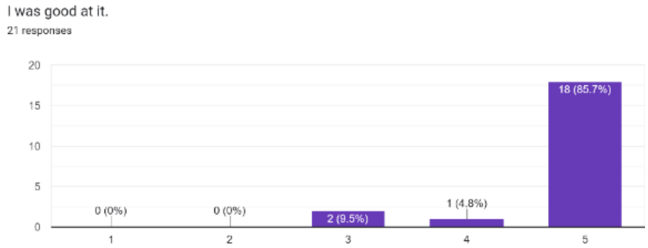

Fig. 13. The result of the game being fun

Fig. 13 shows the results of the respondents that were good at the game. It shows that the majority (76.2%) strongly agreed that they were good at the game. A smaller portion of respondents (4.8%) agreed, and another 9.5% were neutral. This shows that participants felt confident and proficient in their ability to play the game, indicating that the game was accessible and provided an experience where players could achieve a sense of competence.

The findings demonstrate that *AR Mystery Puzzle Game* successfully engages young children, aligning with [4] findings on the efficacy of game-based learning in early childhood. The high scores in immersion (71.4%) support the argument by [20] that AR provides effective scaffolding; the visual overlay helped children understand the problem-solution link without needing complex text instructions.

Unlike passive AR apps (e.g., *Animal Safari AR*), the high "fun" and "competence" ratings here suggest that the *active* problem-solving element (choosing the correct tool) provides a deeper sense of achievement. The fact that most users found it "easy" despite having no prior AR experience indicates that the UI design successfully minimized cognitive load, a key requirement for this demographic [27].

V. CONCLUSION

This research accomplished all its objectives and served as a valuable guide and structure throughout the development process. The objectives helped to guide the proposed prototype's progress and ensure its success.

The primary objective is to assess the prerequisites for developing an educational AR mystery puzzle game for children aged 4 to 6. These criteria are discussed which focuses on AR in education and game strategies for young children.

The next objective was to create a mobile game for children aged 4 to 6 that uses AR (AR). During the research and development phase, the waterfall approach was chosen. The requirement analysis was addressed, and the game's process flow was depicted using a flowchart for clarity. The proposed prototype design includes the selection of an AR SDK, a database design with a diagram and database selection, an interface design showcasing the game's scenes, and a testing environment design outlining the game's testing methods.

The research's final objective was to examine and test the game with its intended audience, children aged 4 to 6. Their input was collected to evaluate the game's usability and overall user experience. This goal was to discover how the game was perceived by users and to assess its efficacy.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

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