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Jungle Math: An Educational Mobile Games for Preschoolers Learning Mathematics

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Abstract: This project is about developing an educational game for kindergarten children. Educational games for kids are designed to teach important concepts such as numbers, letters, colours, shapes, and more in a fun and engaging way. They can also help develop important skills such as problem-solving, critical thinking, and creativity. Mathematics is a challenging subject for most children at an early age, especially preschoolers. This is due to the lack of understanding, interest, and successful ways to help them learn. Typically, mathematical games are presented with an emphasis on entertainment or education. Games can be an effective way to teach children mathematics. They can also help foster a positive attitude towards the subject, which can lead to better learning outcomes. Thus, creating an educational mobile game would be an excellent solution to this problem. This project aims to create a mobile game that can be installed on mobile phones or tablets to teach children mathematics. The RAD (Rapid Application Development) model will be used as the project methodology to conduct this project. First, the functional requirements were determined. Then, the prototype was developed and named Jungle Math. A field usability test was conducted with the targeted users to evaluate the application's ease of use. The findings suggest that the application is ready to be used in a learning and fun environment for kindergarten children upon the success of the trial run, as the targeted users found the application easy to use and enjoyed playing and learning with the application.

Keywords: Kindergarten children, mobile game, mathematics, learning, fun

1. Introduction

The Jungle Math Game Application is a mathematical mobile game application. This application is to help kindergarteners learn mathematics in a more entertaining, creative, and fun way. This means that the application will provide a variety of games with math concepts for children to choose and play. From this, the application will help record the level of understanding through the scoring points. Parents may observe their child's level by reviewing the points earned while playing educational games. This project could help preschoolers to gain knowledge and enjoy learning mathematics. The game will make learning mathematics much more fun and engaging. Children will learn mathematics the easy way without the need for a physical teacher. This project will allow children to learn mathematics in a fun way wherever they are, as the game will be mobile. As technology becomes a necessity in everyone's life, it indeed has a part in the field of education as well.

It is well known that several educational games are available today, and the majority focus on basic subjects like mathematics and science [1], [2]. This helps to broaden the minds of the children. However, children continue to struggle

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in those areas, particularly in mathematics. This is primarily due to children's lack of interest and comprehension [3]. One of the main issues is that children struggle with Mathematics in kindergarten. Mathematics may be enjoyable and challenging for some preschoolers, but it is quite the opposite for others. Working with figures and mathematical concepts may cause math anxiety in many children, causing them to develop a fear of mathematics and stress [4]. Math anxiety is comparable to examination pressure due to right and wrong answers in math, which can overwhelm children who may be nervous or fearful of failure [4]. They may be upset about not having correct answers or comprehending what is being taught. They may become irritated and unhappy due to their poor performance in mathematics, and they may acquire a hatred for the subject, making the development of mathematical skills much harder. Interactional games are vital in teaching and learning strategies to create a learning environment. As a solution, an educational game that requires a cognitive response from students and provides both involvement and enjoyment ought to assist traditional learning resources and support the child's knowledge absorption [5].

Mathematical games are usually delivered mainly focusing on the entertainment or educational aspects. Many educational games focus on both together. These two aspects should be combined to bring a whole new idea. In education, games could be utilised better due to the conflict between the objective of the games and their learning objective [6]. Kindergarten children between 4 and 6 are more attracted to fun things. This means they get easily distracted or bored if something only captures their attention briefly. To solve this, games must be carefully planned and designed. The game must be simple enough for kindergarteners to grasp. Playing mathematical and numbers-oriented games is an excellent method to make math entertaining and get kids interested in learning it. This implies that not only will the game be enjoyable, but it will also be educational since children can learn and gain information while playing [7].

Besides that, some games do not have any reward system to keep children interested in playing continuously. Children need encouragement and motivation not only while playing games but in other things as well. Implementing a score structure is a good suggestion in doing so. This can be done by increasing scores or giving gold stars based on working memory, critical thinking, and problem-solving measures. According to [8], a high score can offer extra Motives, therefore external motivators like commendations or awards, are common in the cognitive learning technique. Children can improve themselves by aiming for higher scores than they previously received with the help of rewards. Additionally, parents may observe their child's level by looking at the points earned while playing educational games. Children will not quickly become disoriented when playing games since they can balance learning and entertainment.

2. Background and Related Studies

Kindergarten children or preschoolers are children aged between 4 to 6 years old. As they are at the beginning of their learning journey, these children's mathematics abilities are crucial. On the other hand, most children who may not receive the necessary parental support to fulfil their full potential are at the possibility of failing to achieve adequate levels of competence. With the development of informational technologies, learning activities in education need to change. Children learn more effectively in renovated informational and educational environments [9]. It is well known that several gaming applications are accessible to children aged six and under. Despite this, many of the applications need to be educated in the manner that preschoolers require [10]. They mostly use a drill-and-practice approach and apply behavioural practices that fail to utilise digital games' potential to engage children in actual and practical problem-solving scenarios [11]. For that reason, this project is to help kindergarteners learn mathematics in a more entertaining, creative, and fun way. The goal of this project is to create a unique and compelling game that will not only amuse children but also help them enhance their skills in the short and long term. According to past studies, children interested in mathematics during early childhood education will excel in the subject in the later years, implying that math exposure is crucial in the children's learning environment [12]. As a result, computer-based educational games have evolved and have been shown to enhance children's math learning outcomes significantly.

There are similar projects that have been carried out previously to come up with solutions and research reports on math educational games. [13] developed an elementary school math mobile game with features like conceptual maps, tutorials, practice exercises, and testing. It supported teachers, motivated students, and improved math skills. [14] proposed 'PreMath Operations,' an educational mobile game for children that helps them learn math through play. [11] worked on games for preschoolers, enhancing higher-order cognitive skills essential for problem-solving. A summarisation of the contribution and limitations of previous studies is presented in Table 1.

Table 1 - Related work

Authors	Method	Contribution/Finding	Limitations/Future work
[13]	Research and Development (R&D)	Math mobile game for elementary school includes various features such as conceptual maps, tutorials, practice exercises, and testing	Not fully implementing all the stages of the Research and development process and the game's limited use on Android operating systems

[14]	Low-fidelity and high-fidelity prototypes and usability test	The study provides a strategy for an engaging and fun math-educational game for children.	The prototype contained two levels with basic animations and pictures. The prototype lacked some levels, including video and sounds
[11]	Observation, game-play capture, and semi-structured interviews	The study focused on young children's problem-solving strategies when playing games and found that children used higher-order cognitive processes instead of only trial and error.	Further research should focus on developing games that promote higher-order thinking skills like critical thinking, inquiry, and problem-solving

3. Methodology

This project used the Rapid Application Development model, also known as RAD for short, as it is a form of agile software development methodology that prioritises rapid prototype releases and iterations. This methodology saves time and resources on planning and introduces the application through prototyping [15]. A prototype is a product model that closely resembles the final product and can perform the same tasks, allowing for a faster delivery of the constructed sample. The main advantage of a RAD model is the quick project cycle, which makes it a practical option for this project, particularly for software development [16]. The focus of RAD on simplifying the planning phase and emphasising prototype development allows for such a quick pace. The stages of the RAD model are depicted in Fig. 1.

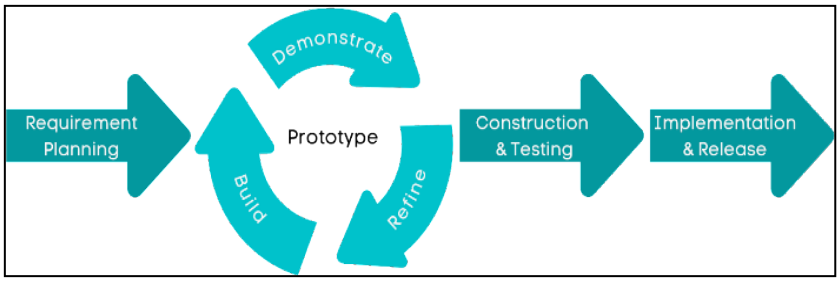

Fig. 1 - Rapid Application Development (RAD) model phases

In the first phase, requirement planning, the project requirements were clearly planned out and defined [17]. This was done by asking and interviewing kindergarten teachers and children and also researching more on existing projects. The project problems and questions surrounding it were identified with the objectives in the related problem statement. Then, the goals and specifications were defined early in the mobile game application development stage. The present and potential problems were highlighted during this phase.

The second phase is the prototype, where the application development begins [18]. A use case diagram was drawn to determine the actors involved and the system's flow. The software and hardware were defined during this phase to ensure what will be used in the development. The primary purpose of this phase is to complete the design version by iterating on numerous prototypes. Design and testing of a prototype took place and all of the bugs and issues were sorted out iteratively after that. Then, in the following design version, all faults were uncovered, and criticisms were considered. A final tested design version was put into software after this phase.

For the third phase, construction and testing, the prototype was placed in beta systems and converted into a functional mobile gaming application [15]. GDevelop 5 was used as the platform to develop the game, which uses the drag-and-drop option to build the game. To do this, the system was thoroughly tested and retested to ensure that it performs as intended, according to the anticipated requirements, objectives, and expectations. It was tested by having kindergarten children and teachers interact with the application and distributing surveys or questionnaires for users to provide feedback by answering specific questions [19]. The application is considered ready for the final release phase if it has completed all testing processes.

Lastly, in the final phase, Implementation and Release, the implementation was done when the final mobile game application was released [17]. Data conversion, testing, switching to the new system, and user training are all included. Screenshots of the design have also been shared, explaining how the program works. During this phase, the application's maintenance has been reviewed and modified depending on user input.

3.1 Design and Development

Clear system requirements, as defined by stakeholders' expectations and user needs while considering limitations, are crucial for effective task development [20], [21]. This section introduces the requirement specification document that specifies all system requirements that govern the development and implementation of the Jungle Math

Game Application. It provides the purpose and scope of the system and the definition of terms specific to the system. The purpose is to describe the Jungle Math Game Application's functional and non-functional requirements. The application is a mobile app that allows kindergarten children to learn Mathematics in a fun and interactive way. This means that the application provides a variety of games with math concepts for children to choose and play. From this, the application helps record the level of understanding through the scoring points. The application has a jungle theme and mathematical games. Hence, the title is Jungle Math Game Application.

Jungle Math Game Application is a mobile game application aimed mainly at preschoolers as the User. The user can browse the list of educational games the application provides and choose which game to play. Once the user selects a game, the game must be played according to levels. The score or points for each group are recorded based on stars earned. The user can only access this application through mobile devices. Jungle Math Game Application used GDevelop 5 as the development platform. No coding is needed in the development as the platform uses drag-and-drop features. Table 2 and Fig. 2, 3, and 4 cover requirement definitions, use case diagrams, activity diagrams and class diagrams.

Table 2 - Functional requirements

Requirement ID	Requirements Description	Priority
JMGA_01	***View educational games***	
JMGA_01_01	Users can browse through the list of educational games.	Mandatory
JMGA_01_02	Users can choose which game to play.	Mandatory
JMGA_01_03	Users can choose to continue the game.	Desirable
JMGA_01_04	Users can choose to exit the game.	Desirable
JMGA_02	***Create user profile***	
JMGA_02_01	Users can create profiles of their names.	Mandatory
JMGA_02_02	Users can choose to change their name according to preference.	Optional
JMGA_02_03	Users can choose their avatar.	Desirable
JMGA_03	***View scores***	
JMGA_03_01	Users can view scores based on each game.	Mandatory
JMGA_03_02	Users can choose to reset scores if needed.	Optional
JMGA_04	***View rewards***	
JMGA_04_01	Users can view rewards based on each game.	Mandatory
JMGA_04_02	Users can claim rewards.	Mandatory
JMGA_05	***Change system settings***	
JMGA_05_01	Users can adjust the background sound volume.	Mandatory
JMGA_05_02	Users can mute background sound.	Desirable
JMGA_06	***View application background***	
JMGA_06_01	Users can view the developer.	Desirable
JMGA_06_02	Users can view instructions for each game.	Mandatory
JMGA_07	***Manage application***	
JMGA_07_01	Admin can fix bugs.	Mandatory
JMGA_07_02	Admin can add features.	Mandatory
JMGA_07_03	Admin can remove features.	Mandatory

A use case model for the system consists of 2 actors and six use cases, namely view educational games, create a user profile, view scores, change system settings, view application background, and manage the application as illustrated in Fig. 2.

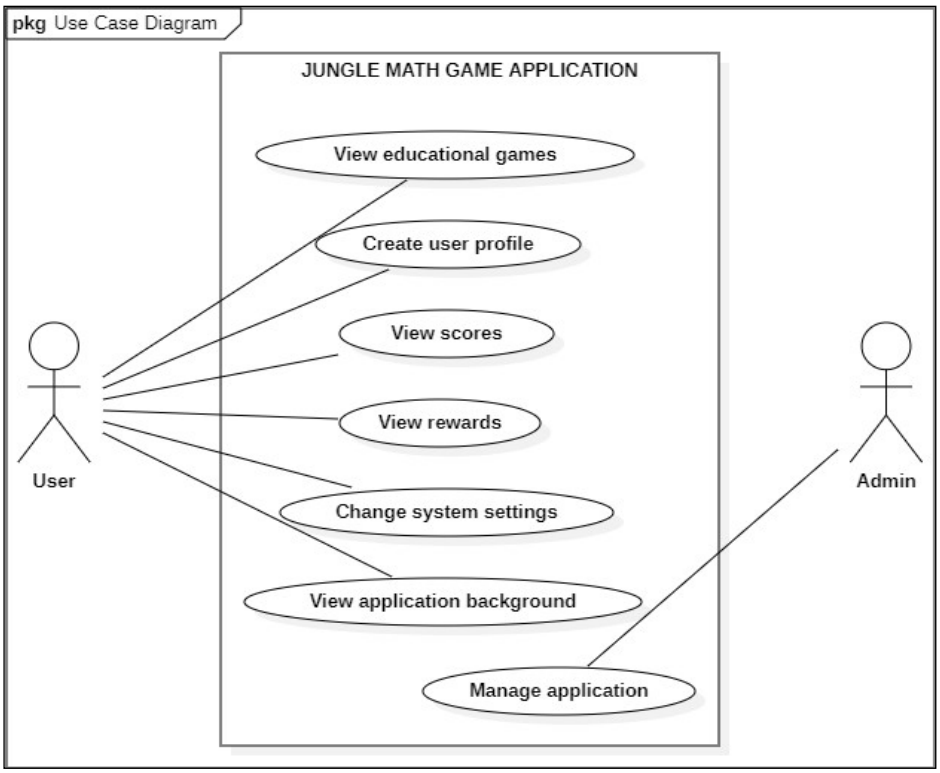

Fig. 2 - The Use Case Diagram

The use case diagram is detailed to show the application's dynamic behaviour. Hence, the operations involved in using the application are illustrated in a self-explanatory activity diagram of Fig. 3.

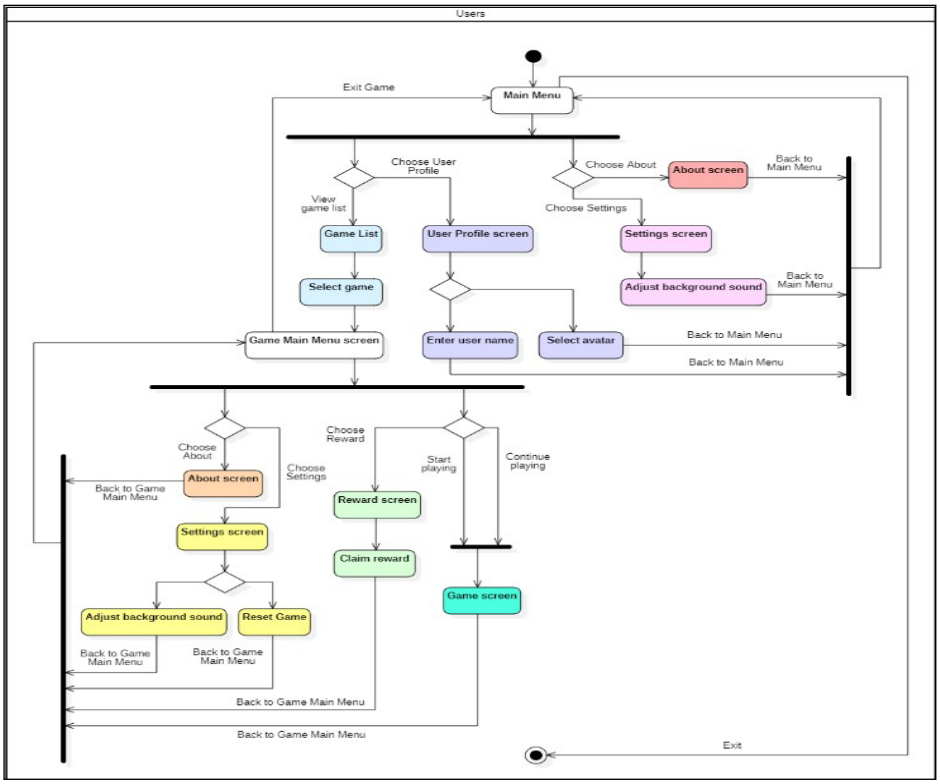

Fig. 3 - The Activity diagram

The application's structural components, attributes, and operations are illustrated in a class diagram in Fig. 4, together with the class interactions.

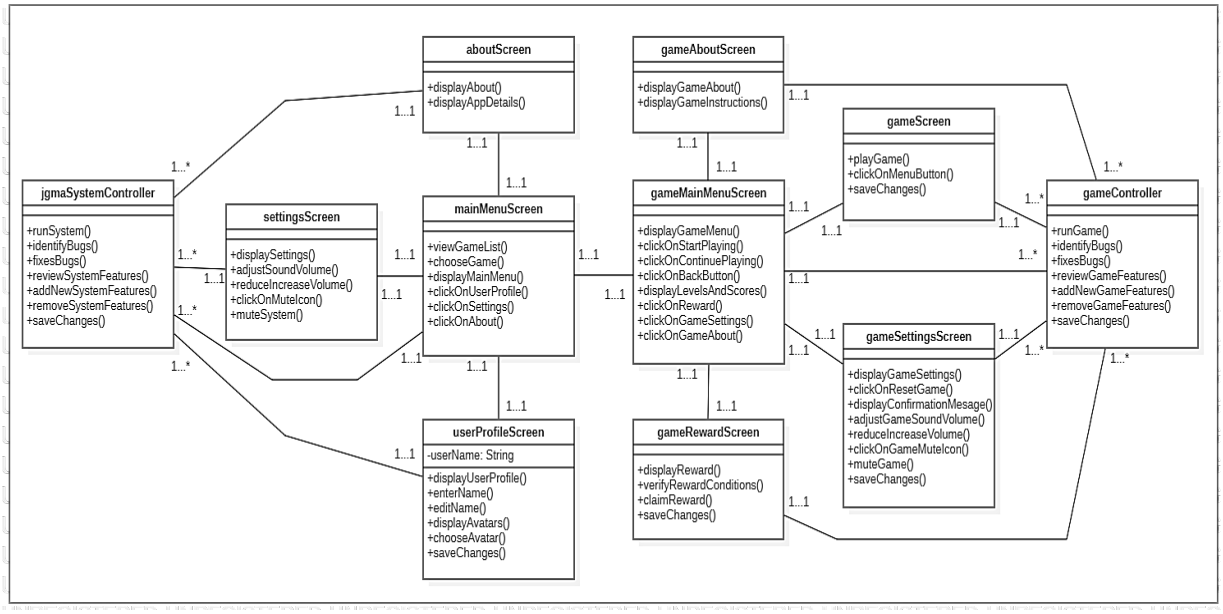

Fig. 4 - Class Diagram

3.2 Prototype Development

Fig. 5 shows the main menu screen for the application when the user opens or accesses the game. The application's main menu screen consists of about, settings, and user profile buttons. The user can also view the educational games and choose which one to play. If the user wants to exit entirely from the game application, the user can press the exit button on the top left.

Fig. 5 - Application main menu screen

The user can view the developer's background by pressing the About button in the application's main menu. The application will then display the about screen, as shown in Fig. 6, which mentions information on the developer and the application itself. Not forgetting, there is a close button at the top left corner of the screen for when the user wants to return to the application's main menu.

Fig. 6 - Application about screen

Next, the user can make system changes by pressing the settings button in the main menu application. The settings screen consists of toggle switches for music and sound for the user to switch on and off. The system's volume can also be adjusted by increasing and decreasing the volume section. These can be seen in Fig. 7.

Fig. 7 - Application setting screen

Fig. 8 depicts the user profile screen, accessed when the user presses the user profile button in the main menu. Through the user profile screen, the user can create a profile of their own by entering their preferred name into the text box provided and choosing an avatar to represent them. The save button at the bottom of the screen will save any changes made.

Fig. 8 - User profile screen

Returning to the application's main menu screen, the user can choose which game to play out of five (5) games from the list provided in the main menu. Once the user selects a specific game to play, the application will display the

chosen game's main menu screen for a specific game to play. Fig. 9 shows an example of one of the game's main menu screens. As can be seen, the game's main menu provides buttons for instructions, settings, play, and reward, and also an exit button to exit from the fun back to the application's main menu. The tiles at the bottom of the screen represent the levels of the game the user has played, while the ones with the lock icon represent levels that are yet to be unlocked. Each class also records the scores obtained by the user.

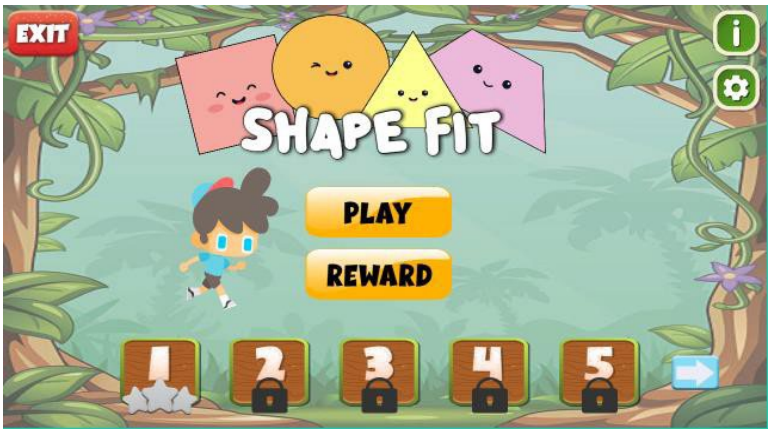

Fig. 9 - Game main menu screen

Fig. 10 shows the instructions screen of the chosen game when the user presses the instructions button in the game's main menu. In the instructions screen, simple instructions for the game are displayed step-by-step on how to play the game. A close button on the top left of the screen leads the user back to the game's main menu when pressed.

Fig. 10 - Instruction screen

As shown and stated previously, the game settings screen in Fig. 11 provides the same functions as in Fig. 7 for the application's settings.

Fig. 11 - Game setting screen

From the game's main menu screen, the user can press the play button to start playing the game based on the level they are currently on. The system will directly display the game screen, as shown in Fig. 12, where the user can start playing the game. In the game screen, a menu button is illustrated in Fig. 13.

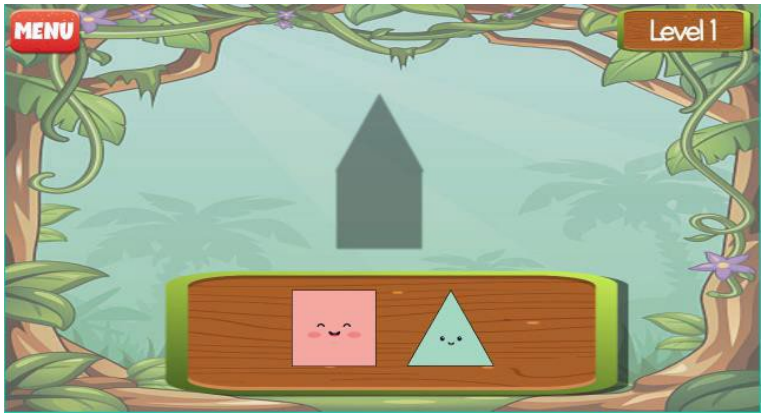

Fig. 12 - Game screen

A pause menu will appear when the user presses on the menu button in the game screen. Fig. 13 shows that the pause menu allows the user to pause the game and continue playing again by pressing the continue button, to restart the game level by pressing the restart button, and to exit from playing the game to go back to the game's main menu by pressing the quit game button.

Fig. 13 - Pause menu

Fig. 14 - Reward screen

Lastly, the reward screen in Fig. 14 shows the rewards the user can achieve once they have collected a certain

number of scores. Each tip has a condition to be fulfilled. The percentage bar will be filled according to the number of scores collected.

3.3 Usability Evaluation

The type of evaluation conducted to evaluate the application was through usability evaluation [22]. To carry out the evaluation, two usability evaluation methods have been used: field usability testing and a questionnaire [23]. During the usability testing, participants assessed the application while cautiously observing their actions, facial expressions, behaviour, and emotional responses [22]. After that, a usability questionnaire was carried out by addressing specific questions to participants to understand their appraisal and thoughts regarding the system [24]. This evaluation was conducted with 16 participants including three teachers from Taska Al-Aufa, Changlun, Kedah and Tadika Islam, Gelugor, Penang. The instruments or equipment used in the assessment consist of a mobile phone with the Jungle Math Game Application installed. Participants provided feedback on the application by filling out a questionnaire. The questionnaire was used to measure the game prototype's ease of use, usefulness, and satisfaction with the game [25], [26]. In this questionnaire, there are two (2) sections: section a and section B. Section A is based on demographics. Responses to section B are based on game usability. The procedure taken to undergo the evaluation is as follows: (1) the developer explains the purpose and procedure, (2) the kindergarten teachers read the information sheet and sign the consent form on behalf of the kindergarten children, (3) one by one, the participants interact with the application from every aspect while the developer observes the entire interaction, and (4) the participants answer the post-task questionnaire with the guidance of the developer.

Fig. 15 - Developer explaining to participants

Fig. 16 - Participants interacting with the application

4. Results and Discussion

In this section, the results of the evaluation part are presented in the following subsections.

4.1 The Participants' Demography and Background Information

Sixteen participants took part in this study. The study collected data about their age, gender, and other information regarding electronic device usage including games. Table 3 summarises the data from section A in the questionnaire.

Table 3 - Demographics

Question	Answer	Number	Percentage
Participant type	Preschoolers	13	81.25%
	Teachers	3	18.75%
Gender Distribution	Male	8	50%
	Female	8	50%
Age Groups	3 - 4 years old	8	50%
	5 - 6 years old	5	31.25%
	Teachers (other category)	3	18.75%
Electronic Device Usage	Daily	11	68.75%
	Weekly	5	31.25%
Purpose of Electronic Device Usage	Games	9	56.25%
	Not playing games	5	31.25%
	Not sure	2	12.5%
Played Mathematical-related Games	Yes	8	50%
	No	4	25%
	Need clarification	4	25%

Based on the results from Table 3, analysis of the demographic information revealed two categories of participants: Teachers and preschoolers. Most of the participants were preschoolers, as there were 13 (81.25%). The gender distribution was even. Among the preschoolers, 50% were between the ages of 3 - 4, and 31.25% were aged 5 - 6. Three teachers were also part of the study, contributing to the "other" category.

In terms of electronic device usage, the participants use electronic devices quite often whereby the majority of participants (68.75%) reported using electronic devices daily, while 31.25% used them weekly. Regarding playing mathematical-related games on electronic devices, 50% of participants had played such games, while 25% had not, and another 25% needed clarification. Among those who played mathematical games, 50% had played other games as well. Regarding playing mathematical-related games on electronic devices, 50% of participants had played such games, while 25% had not, and another 25% needed clarification. Among those who played mathematical games, 50% had played other games as well. The duration of playing mathematical games varied, with 31.25% playing for more than an hour but less than two hours, 12.5% playing for less than an hour, and 6.25% playing for more than two hours but less than five hours.

The study involved both teachers and preschoolers, highlighting the importance of considering the perspectives of both educators and young learners when assessing the use of educational games [6], [14]. The even gender distribution suggests equal representation. The majority of participants used electronic devices daily, with varying usage durations. This suggests that daily usage is common among both teachers and preschoolers, potentially providing opportunities for educational interventions [27]. A significant portion of participants used electronic devices for gaming, including mathematical-related games. This emphasizes the potential for incorporating educational content into games to support learning [28]. In conclusion, the study provides valuable insights into the demographic composition and electronic device usage patterns among teachers and preschoolers. These findings can inform the design of educational games that cater to the diverse needs and habits of young learners and educators. Further research could delve deeper into the educational outcomes and preferences associated with different usage patterns.

4.2 Participants' Response Towards Jungle Math Game Application

The data collected for section B were summarised and evaluated for its effectiveness. This section measures the participants' perception of the Jungle Math Game Application's usefulness, ease of use, and satisfaction. Table 4, 5, and 6 reports the responses that range from strongly disagree to agree strongly.

Table 4 - The usefulness of jungle math game application

The Usefulness of Jungle Math Game Application	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I like the game without any login features.	0 (0.00%)	0 (0.00%)	0 (0.00%)	6 (37.50%)	10 (62.50%)
I need a login to access the application.	0 (0.00%)	0 (0.00%)	0 (0.00%)	4 (25.00%)	12 (75.00%)
I can learn mathematics better with the application.	0 (0.00%)	0 (0.00%)	5 (31.25%)	5 (31.25%)	6 (37.5.0%)
The application makes me feel interested in playing	0 (0.00%)	0 (0.00%)	3 (18.75%)	9 (56.25%)	4 (25.00%)

In assessing the usefulness of the Jungle Math Game Application (Table 4), the majority of participants express a strong preference (62.50%) for the game's absence of login features, while a significant portion (75.00%) equally strongly believes that a login is necessary to access the application. Opinions on the application's efficacy for learning mathematics are divided, with 31.25% remaining neutral, 31.25% in agreement, and 37.5% strongly agreeing that it enhances learning [13]. Additionally, a majority of participants (56.25%) report a keen interest in playing the game, reflecting a positive reception of the application's appeal and user engagement potential.

Table 5 - Ease of use of jungle math game application

Ease of Use of Jungle Math Game Application	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I like the layout of the application.	0 (0.00%)	0 (0.00%)	0 (0.00%)	8 (50.00%)	8 (50.00%)
I like the colours used in the application.	0 (0.00%)	0 (0.00%)	0 (0.00%)	10 (62.50%)	6 (37.50%)
I like the pictures used in the application.	0 (0.00%)	0 (0.00%)	0 (0.00%)	4 (25.00%)	12 (75.00%)
I like that the application has a reward system.	0 (0.00%)	0 (0.00%)	8 (50.00%)	5 (31.25%)	3 (18.75%)
The application is slow and lagging when I play.	9 (56.25%)	7 (43.75%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
The game levels need to be simplified.	2 (12.50%)	5 (31.25%)	5 (31.25%)	3 (18.75%)	1 (6.25%)

In evaluating the ease of use of the Jungle Math Game Application (Table 5), participants overwhelmingly express strong agreement with several aspects of the application's design: 50.00% strongly agree that they appreciate the layout, 62.50% strongly agree with the use of colours and a substantial majority of 75.00% like the pictures incorporated into the application. A majority of participants (50.00%) also appreciate the inclusion of a reward system [13], with none indicating strong disagreement or disagreement. However, there are concerns among some participants (56.25%) regarding the application's performance, as they find it slow and lagging. Furthermore, opinions on whether game levels need simplification are mixed, reflecting diverse user preferences and experiences.

Table 6 - Satisfaction of jungle math game application

Satisfaction of Jungle Math Game Application	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am happy with how the application is.	0 (0.00%)	0 (0.00%)	3 (18.75%)	10 (62.50%)	3 (18.75%)
I recommend the application to my friend.	0 (0.00%)	0 (0.00%)	6 (37.50%)	7 (43.75%)	3 (18.75%)
I will use this application again.	0 (0.00%)	0 (0.00%)	7 (43.75%)	8 (50.00%)	1 (6.25%)
The application is lovely and pleasant to use.	0 (0.00%)	0 (0.00%)	0 (0.00%)	8 (50.00%)	8 (50.00%)

Regarding participants' satisfaction with the Jungle Math Game Application (Table 6), the majority express contentment, with 62.50% agreeing that they are happy with the application. A substantial portion (43.75%) also indicates a willingness to recommend the application to friends, reflecting a positive user experience. Additionally, 50.00% of participants intend to use the application again, indicating a favourable inclination towards continued usage. Furthermore, a strong majority (50.00%) strongly agree that the application provides a lovely and pleasant user experience, highlighting its user-friendly and enjoyable qualities. These findings collectively suggest a high level of satisfaction and user engagement with the application, boding well for its educational effectiveness and user retention [7].

The evaluation results indicate that the Jungle Math Game Application has been positively received by participants. They find it useful, easy to use, and satisfying. The lack of a login feature is appreciated, and many participants believe they can learn from the application. The application's design, including layout, colours, and pictures, received positive feedback. While the majority of participants enjoy the application's reward system, there are concerns about slowness during gameplay. Additionally, opinions on game-level complexity vary.

Overall, participants expressed satisfaction with the application, as they reported happiness, willingness to recommend it to others, and intent to use it again. The application is perceived as lovely and pleasant to use, which bodes well for its educational effectiveness and user engagement.

5. Conclusion and Future Works

This paper delineates the design and implementation of an educational mobile game application tailored to enhance mathematical skills in kindergarten children. The study outlines a specialized approach to crafting a mathematics educational game tailored to this age group and evaluates the outcomes observed with the Jungle Math Game Application. The findings affirm that the application's design has a notably positive impact on facilitating skill development in children. The study employed a comprehensive data-gathering process, thereby enhancing control over the data relevant to the proposed design. For future research endeavours, this application design strategy can serve as a valuable foundation for further development, encompassing an expanded repertoire of math-related games that offer diverse challenges. Moreover, ongoing efforts should be directed toward rectifying performance-related issues and refining game difficulty levels to cater to varying user requirements. This research contributes to the broader community by providing educators and parents with a valuable tool to effectively educate and engage kindergarten children. Ultimately, this application holds the potential to foster enhanced mathematical proficiency among young learners, thus successfully fulfilling its defined objectives through its developmental journey.

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