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Transforming Learning Mathematics through Interactive Mobile Games (iMOBIMATH)

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ABSTRACT

iMOBIMATH is a fun and engaging mobile app designed to make math learning an exciting adventure for young children in Malaysia. The apps were created for kids aged 4 to 6 years old where it turns numbers, shapes, and basic math concepts into interactive play, helping little learners build confidence while having fun. Some common problems children face in such as struggling to understand simple operations like adding or subtraction, count objects correctly and mixing up the sequence of numbers. A quantitative research approach was adopted which is ADDIE Model. The model consists of Analysis, Design, Development, Implementation and Evaluation. The application covers fundamental operations such as addition and subtracting. The application is built to be simple, fast, and efficient, ensuring a smooth experience for Android based. The questionnaire is designed in English and given to kindergarten students in Melaka with the guidance and support of their teachers. This ensures that the children can understand and respond comfortably while making the process smooth and engaging for them. The sample collected is 30 sample. The findings indicate a significant positive learning experience, with an overall mean score of 4.76 for the application. This suggests that users generally found it easy to use and effective for learning mathematics. In conclusion, iMOBIMATH transforms early math learning into a joyful and interactive experience for children aged 4-6 in Malaysia. By combining engaging activities, playful visuals, and an intuitive design, the app fosters a strong foundation in mathematics while keeping young learners motivated and confident.

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1. Introduction

The advancement of technology has transformed the education sector by integrating innovative learning approaches, including mobile game-based learning. With the prevalence of smartphones and mobile devices, mobile game-based learning has garnered considerable attention as a significant tool for offering accessible and convenient learning opportunities to a broad audience [1]. Students today are growing up in an increasingly technology-driven world and are becoming more accustomed to using technology. They were grown using digital tools. Significant issues in adapting the learning process to students with various learning preferences must be addressed by educators. One of the educational strategies and methods that increase students' motivation and engagement is gamification [2]. These skills are crucial for fostering the development of 21st-century competencies like computational thinking and computer programming. Concurrently, educational games have become a prevalent activity in numerous educational settings. However, research indicates that many of these games fail to engage the audience [3].

Games related to geometry, measurement, and numbers demonstrate a moderate level of alignment with their respective content domains, whereas those focused on data and algebra exhibit a weaker correspondence between content and context [4]. The potential advantages of utilizing digital games for educational purposes have not escaped the attention of researchers [5]. Students exposed to problem scenarios presented in engaging and thought-provoking contexts have shown significant improvements in their problem-solving skills through the use of educational digital games [6-10]. Consequently, educators have considerable research effort to understanding this problem-solving phenomenon within gaming environments in recent decades [11,12]. The nature of the new technology interweaves formal and informal learning such that students can participate actively in the use of ICT to learn [13].

In recent years, the integration of mobile applications into educational settings has revolutionized traditional approaches to learning, particularly in subjects like mathematics. The smartphones and tablets have made learning more accessible and engaging than ever before, with mobile apps offering innovative ways to interact with mathematical concepts. Among the various types of educational apps, those utilizing interactive games have emerged as particularly promising tools for promoting mathematical proficiency among students of all ages. In research and development, the game method has become more and more prevalent. The traditional methods of teaching mathematics often involve rote memorization, repetitive exercises, and abstract concepts that can be challenging for many students to grasp. However, mobile apps for learning mathematics leverage the inherent appeal of gaming to make the learning process more enjoyable, interactive, and effective. By combining educational content with elements of gamification, these apps transform mundane mathematical exercises into engaging challenges that captivate students' attention and foster a deeper understanding of mathematical principles.

They can elevate the quality of learning and create an effective learning environment by turning learners into active participants and fostering their motivation [14-16]. Additionally, games serve as potential educational tools for enhancing comprehension and learning complex subjects [14]. Some key themes identified in game design include creativity, customization, diverse characters, collaborative interaction, and non-violent exploration. It is recommended to carefully consider elements such as storytelling, background narratives, social engagement, visual aesthetics, and personalized features [17]. Numerous research investigations exploring the use and impact of educational digital games in mathematics learning environments highlight the crucial role these games play in improving students' mathematical knowledge and problem-solving abilities [6,18,19].

Moreover, the aspect of enjoyment significantly contributes to students' eagerness to learn, thereby bolstering their overall motivation [20-26].

The appeal of mobile apps for learning mathematics lies in their ability to leverage the ubiquity of mobile devices and capitalize on the inherent motivation that games provide. With interactive features such as puzzles, quizzes, simulations, and challenges, these apps create dynamic learning environments that encourage exploration, experimentation, and problem-solving. Through hands-on engagement with mathematical concepts, students can develop essential skills such as critical thinking, logical reasoning, and mathematical fluency in a context that is both meaningful and enjoyable. Researchers have confirmed the efficacy of digital games in the teaching and learning process [21]. Utilizing digital learning platforms becomes crucial for offering enduring learning opportunities to students immersed in technology from a young age.

Furthermore, mobile apps offer flexibility and accessibility, allowing students to learn at their own pace and on their terms. Whether in the classroom, at home, or on the go, students can access a wealth of interactive mathematical resources at their fingertips, supplementing traditional instruction and providing opportunities for personalized learning experiences. Additionally, many mobile apps incorporate adaptive algorithms that tailor the learning experience to individual student needs, ensuring that learners are appropriately challenged and supported as they progress through mathematical concepts. In this context, this study explores the landscape of mobile apps for learning mathematics using interactive games. Through an examination of their features, benefits and potential impact on mathematics education, we seek to elucidate the role of these apps in promoting mathematical proficiency and engagement among students. Through leveraging technology and gamification, mobile applications possess the capability to transform the landscape of mathematics education, rendering it more accessible, interactive and enjoyable for learners globally.

There has been a popularity of online and interactive educational games aimed at enhancing and accelerating the learning journey for students. These educational entertainment games employ multimedia elements to enhance children's memorization skills and proactive learning. These games have gained popularity as a main ingredient methodology and can effectively involve local communities. In the field of higher education, asynchronous gamified environments have revolutionized pedagogical approaches, profoundly shifting how knowledge is constructed, delivered, and elaborated through learner interactions [27,28]. The introduction of gamification elements led to increased student engagement and participation [29]. In addition, learning though valuable for studying peer learning in digital settings like gamified environments, has not been widely used in college business courses [30-32].

This study accordingly aims to bridge the gap by leveraging learning analytics techniques epistemic network analysis and sequence pattern mining to explore interaction dynamics among college business students in asynchronous gamified environments. By identifying interaction patterns, the study seeks to enhance understanding of how learners engage in knowledge co-construction in this context. Technology-wise, international research shows a prevalent use of computer-based platforms and a rising interest in mobile technologies, a trend mirrored in Iranian studies, albeit with a noticeable lag in adopting newer technologies [33]. Game-based learning researchers have been investigating various means to maximize learning in educational games. One promising venue in recent years has been the use of learning analytics in online game-based learning environments [33]. The implication for educational game development is whether similar types of activities, ones that are not related to content but specifically designed to heighten emotional attachment and a sense of flow, should be considered an integral part of games that are designed for students to practice complex and difficult skills [34].

2. Methodology

The ADDIE model preserved this characteristic of five steps, incorporating numerous sub-stages within each of the five overarching phases. Given the hierarchical arrangement of the steps, practitioners were required to follow a linear progression, completing one phase before moving on to the next. The acronym ADDIE represents Analyze, Design, Develop, Implement, and Evaluate shown in Figure 1. This model of Instructional Design has endured over time and extensive usage. It serves as a framework to guide our thinking process when designing a course. This sequence does not mandate a strict linear progression through the stages. Educators, instructional designers, and training developers appreciate this approach because well-defined stages make it easier to implement effective training tools.

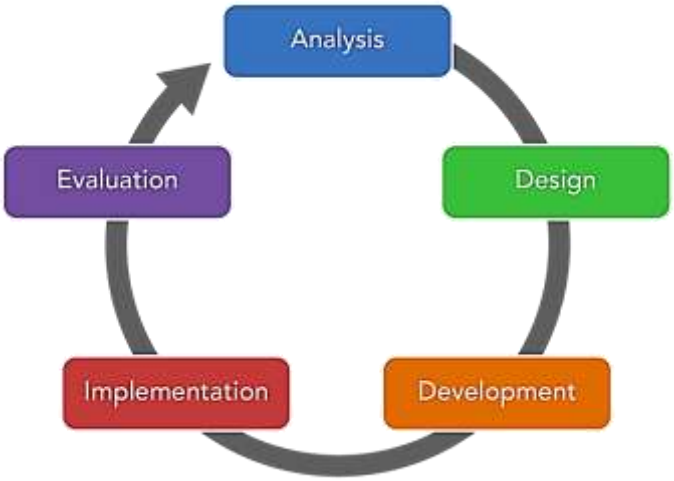

Fig. 1. ADDIE model

In Analysis phase, the designer's attention is centered on the target audience, ensuring that the program aligns with the skill level and intelligence of each student or participant. The aim is to avoid duplicating what they already know and instead focus on topics and lessons that are new to them. Instructors in this phase differentiate between the student's existing knowledge and what they should acquire upon completing the course. All objectives, performance evaluation tools, assessments, subject matter analyses, plans, and resources are established during the Design phase. During the design phase, the focus is directed towards learning objectives, content, subject matter analysis, exercises, lesson planning, assessment instruments, and media selection.

The Development stage marks the beginning of producing and testing the methodology utilized in the project. Throughout this phase, designers leverage the data collected from earlier stages to create a program that efficiently delivers the required teachings to participants. If the preceding stages were characterized by planning and brainstorming, the development stage concentrates on execution. The Implementation stage represents the ongoing adaptation of the program to ensure maximum efficiency and favorable outcomes. This is where instructional designers endeavor to refine, refresh, and adjust the course to ensure effective delivery. "Procedure" is the focal point here. A significant portion of the work occurs as instructional designers and students collaborate to familiarize themselves with new tools, enabling continuous evaluation of the design for further enhancements.

Evaluation of the design occurs during the implementation phase, where designers assume a highly involved role pivotal for project success. Developers must continuously assess, redesign, and improve the product for efficient delivery. Diligent monitoring is imperative. Thorough evaluation of

the product, course, or program, along with necessary and timely revisions, is conducted during this phase. Each phase of the ADDIE process incorporates formative evaluation, which is a multifaceted and indispensable aspect of the ADDIE process. Evaluation occurs continuously during the implementation phase with the involvement of both instructors and students. Following the completion of a course or program implementation, a summative evaluation is conducted to enhance instruction. Throughout the evaluation phase, the designer must determine whether issues pertinent to the training program are addressed and whether the desired objectives are achieved.

3. Results

Table 1 displays the results of a participant's survey regarding the Mobile Maths application. Participants were asked to assess their experience with the app by using a scale that spans from 1 (Strongly Disagree) to 5 (Strongly Agree). The overall mean score for the application stands at 4.76, indicating that users generally perceived it as user-friendly and effective for learning mathematics. The dimensions receiving the highest ratings were "Ease of use of the Mobile Maths application," "Understanding of navigation within the Mobile Maths application," and "Clarity of buttons and images," all scoring an average of 4.88. Conversely, the lowest-rated dimension was "Encountering difficulties while using the app," with an average score of 2.06. This implies that while some users faced issues with the application, the majority found it easy to navigate.

The findings suggest that while the Mobile Maths application excels as a competent and well-designed tool for mathematics education, there are opportunities for improvement, particularly in enhancing user-friendliness for those experiencing difficulties.

Table 1
Results of a participant's survey Mobile Maths apps

No.	Item	Mean score	Standard deviation	No.	Item	Mean score	Standard deviation
1.	How easy was it to use the application?	4.79	0.48	9.	Were you aware of where to locate items within the app?	4.8	0.54
2.	Did you understand how to move around the application?	4.79	0.47	10.	Did the Mobile Maths application effectively educates you about mathematics?	4.76	0.5
3.	Did you find the buttons and images easy to understand?	4.88	0.41	11.	Did you find learning from the application enjoyable?	4.8	0.54
4.	Did you encounter any issues while using the app?	2.06	1.56	12.	Did you understand the concepts taught by the application?	4.82	0.46
5.	Did you locate everything you required?	4.76	0.55	13.	Did anything within the app cause confusion for you?	1.74	1.24
6.	Are you fond of the theme utilized for this application?	4.74	0.57	14.	Would you like to learn anything else from the app?	3.74	1.19
7.	Did you find the colors and images visually pleasing?	4.82	0.46	15.	Would you consider recommending the Mobile Maths application to your friends?	4.82	0.46

8.	Was the font style easy to read?	4.82	0.46	16.	How much do you enjoy the Mobile Maths application?	4.82	0.46

4. Project Significance

Developing mobile apps for mathematics learning for children aged 4 to 6 years involves tasks such as media creation, integration, product configuration management and customized implementation. Each creative reveal mathematical concepts, transforming learning into an engaging adventure for young learners. From guiding characters to illustrations of numbers and shapes, media creation serves as the essence of the application. Additionally, the significance of the project lies in integrating media elements into the app's user interface. This includes strategically placing interactive features, audio, and visual elements to enhance navigation and create an enjoyable experience.

Furthermore, the technical aspect of product configuration management holds significant importance. These procedures guarantee the app's functionality across a range of devices and platforms. As for the implementation progress, it represents the dedication and effort that transforms planning into tangible reality. Additionally, it encompasses the challenges to overcome, the milestones achieved, and the joy of witnessing young learners embracing the apps. The implementation status stands as a significant milestone in impacting early mathematics education positively.

5. Conclusions

In summary, the application provides a comprehensive and engaging learning experience designed specifically for children aged 4 to 6. It is structured to simplify navigation and optimize data processing, creating a user-friendly platform that fosters an enjoyable learning experience. Research suggests that educational digital games contribute to students' academic performance by improving the efficiency of the learning process [6,22,24,35,36].

The application captivating features and extensive content render it a transformative resource for early mathematics education. Additionally, observations emphasize the importance of engaging graphics and characters, with animations and exploration enhancing the gaming experience. This holds not only in recreational and commercial contexts but also in serious applications such as workplace safety, urban planning, defense and healthcare [3,37]. Future works may involve monitoring and analysing children's scores to identify areas needing further assistance and improvement, as well as establishing a platform for parents or teachers to track their children's learning and progress.

The integration of augmented reality (AR) and virtual reality (VR) technologies into mobile math games presents an exciting direction for research. These immersive technologies can create hands-on, interactive environments that allow students to visualize complex mathematical concepts in 3D space, enhancing conceptual understanding. For example, students could manipulate geometric shapes or explore real-world applications of mathematics in a virtual setting. Furthermore, cross-platform compatibility and the ability for mobile games to work seamlessly on different devices can increase accessibility and inclusivity, enabling a wider range of students to benefit from these tools, regardless of their socioeconomic status. Finally, future work should explore the effectiveness of mobile math games in diverse educational contexts, including varied age groups, learning disabilities, and cultural settings. Conducting longitudinal studies to assess the long-term impact of game-based

learning on mathematical proficiency and attitudes towards math will provide deeper insights into the lasting effects of mobile gaming in education.

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