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Interactive Math Adventures for Primary Students (IMAPS)

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Abstract

Mathematics is one of the core subjects for primary school students but still there are many students' lacking confidence and engagement that lead to poor learning outcomes. This led us to develop Interactive Math Adventures for Primary Students (IMAPS), an adventure-based interactive web game designed using Unity and C# to teach basic math concepts through gaming challenge concepts. IMAPS features a knight versus monster battle system in which a correct answer allows students to attack the monster while the wrong answer allows the monster to attack their character; it motivates the students to solve the problems across 30 levels. Features that are included in the game are statistical tracking, progress monitoring, and understanding of basic arithmetic operations. Evaluation results indicate that IMAPS effectively improves student engagement and understanding of basic arithmetic operations. In future, enhancement will focus on expanding the content scope and improving adaptive learning to further personalize the educational experience.

1. Introduction

Mathematics is a key subject in primary education, yet many students struggle to stay engaged using traditional teaching methods. Gamification has emerged as an effective strategy to increase motivation and performance by integrating game mechanics into learning environments. According to Camacho-Sánchez et al. [1], applying motivational models like ARCS enhances student focus and achievement. Ofosu-Ampong [2] also supports gamification's role in improving classroom interactivity. In response, the Interactive Math Adventures for Primary Students (IMAPS) was developed—an educational web game using adventure-based gameplay to reinforce math concepts, aligned with the Malaysian Year 3 curriculum and designed to make learning more engaging.

1.1 Related Works

Gamification has emerged as an effective educational strategy, especially in primary education where engagement and motivation are key challenges. This trend accelerated post-Covid-19, when educators sought

new methods to maintain student interest through remote and hybrid formats. Gamification involves the application of game design elements in non-game contexts to encourage participation and improve outcomes. In math education, especially for young learners, gamified digital tools have shown promise by turning abstract concepts into interactive, visual, and rewarding experiences [1], [2].

1.2 Gamification in Education

Gamification in education enhances motivation, engagement, and academic achievement. Using Attention, Relevance, Confidence, Satisfaction (ARCS) motivational model within gamified learning significantly improves student motivation and learning outcomes [1]. This model is especially relevant in primary education were maintaining attention and building confidence are challenging. Simsek and Karakus Yilmaz [3] found that game elements like points, badges, levels, and leaderboards enhance both cognitive and affective learning outcomes in online learning. Similarly, Zakaria et al. [4] demonstrated that gamified Massive Open Online Courses (MOOCs) improved student retention, completion rates, and motivation. These studies reinforce the value of well-designed gamified systems. Ofosu-Ampong [2] stressed the importance of aligning gamification with instructional goals to ensure that increased motivation translates into meaningful learning. When implemented effectively, game mechanics like rewards, progress tracking, and immediate feedback support learning by reinforcing correct behaviour and making content more engaging. In line with these findings, the IMAPS design integrates points, animated feedback, and level progression through adventure-style gameplay. These mechanics support the Year 3 mathematics syllabus and provide increasingly challenging levels that maintain learner interest while encouraging consistent performance.

1.3 Gamification Taxonomy and its Application in IMAPS

Toda et al. [5] proposed a comprehensive gamification taxonomy that classifies 21 validated game elements across five educational dimensions, offering a framework for purposeful design. In IMAPS, key elements such as points, feedback animations, badges, and level progression were directly inspired by this taxonomy. Each feature was designed to support specific learning objectives such as reinforcing accuracy, encouraging effort, or rewarding persistence.

Khaldi et al. [6] also emphasized that points, badges, leaderboards, and feedback mechanisms are the most used game features in higher education e-learning platforms. Their systematic review suggested that combining these with deeper mechanics like storytelling and adaptive challenges leads to stronger learner engagement. IMAPS adopts this strategy with a narrative-driven structure (knight-versus-monster) and progression-based levels to promote continuous engagement among young learners.

According to Ofosu-Ampong [2], conceptual understanding depends on how well game elements are embedded within educational content. To ensure this, IMAPS uses mathematics questions adapted directly from the Malaysian Year 3 curriculum and adjusts difficulty to suit various learner abilities.

1.4 Limitations and Challenges in Gamified Learning

Despite the benefits, several limitations have been identified in gamified systems. Toda et al. [5] caution against the overuse of superficial elements like points and badges without meaningful integration, which can distract from learning and reduce effectiveness over time. Zakaria et al. [5] further noted that although gamification enhances short-term engagement, its long-term impact is limited without continuous evaluation and adaptation. Simsek and Karakus Yilmaz [3] echoed this concern, stating that many systems lack adaptive features or rely heavily on repetitive rewards, which may lead to reduced motivation. In the current version of IMAPS, challenges such as limited feedback customization and lack of persistent progress tracking were observed, aligning with these broader limitations. Raja Rosli et al. [7] reviewed game-based learning in engineering education and argued for the need to better align gamification with curriculum goals to foster higher-order thinking. They highlighted that systems with analytics, feedback loops, and adaptive pathways are more effective in achieving academic improvement features currently planned for future IMAPS updates. To address common learning challenges like forgetfulness and low confidence, IMAPS applies narrative-based learning, non-punitive feedback, and a child-friendly interface. These elements are designed to support exploratory learning and reduce the anxiety sometimes associated with classroom mathematics [3]. Camacho-Sánchez et al. [1] concluded that when gamification is grounded in motivational theory such as the ARCS model it produces measurable gains in performance and satisfaction. This supports IMAPS's score design, which aims to improve engagement not just through fun, but through structured, theory-driven gameplay. While IMAPS is currently functional in a local environment, future deployment aims to offer browser-based WebGL access for broader use. As Khaldi et al. [6] and Raja Rosli et al. [7] noted, the success of gamified systems depends more on thoughtful instructional design than delivery format. IMAPS builds on this insight by aligning syllabus-based content with interactive, meaningful learning experiences.

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2. Methodology

IMAPS adopts the Waterfall methodology, a traditional and structured software development model. This linear approach divides the project into distinct phases: requirements gathering, design, development, testing, and evaluation each completed before progressing to the next. This model is well-suited for projects like IMAPS, where the objectives, tools, and target audience are clearly defined from the outset.. The Waterfall model provides clarity and a strong sense of direction, enabling the team to systematically develop an engaging, story-based maths game using Unity. According to the project's Gantt chart, each stage follows a logical sequence, ensuring thorough planning, focused execution, and timely delivery. This methodology allows the team to effectively manage time and resources, minimise risks, and ensure high-quality output. By using this approach, the project ensures that educational effectiveness, user engagement, and technical functionality are carefully considered at every step. The phases involved are shown in Fig. 1.

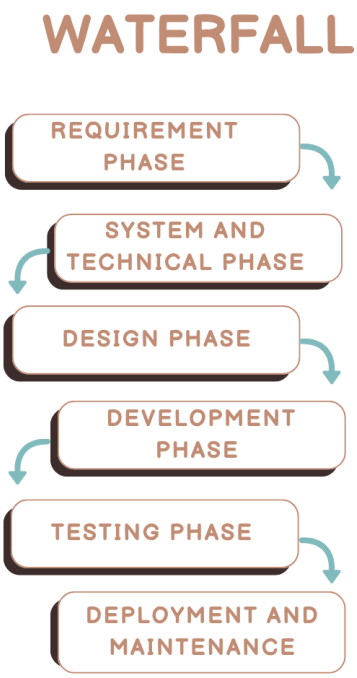

Fig. 1 *Waterfall methodology used in the development of IMAPS*

The project began with the Requirement phase, which was the first and most crucial step in developing the IMAPS (Interactive Math Adventures for Primary Students) application. During this stage, the focus was on gathering and analysing all necessary information to ensure that the application would effectively support the learning needs of Year 3 students. The primary goal for this project is to use the gamification components to increase the student's interest in and enjoyment of mathematics. The concepts that were taught in IMAPS were taken straight from the official Year 3 school textbook to guarantee consistency with the current curriculum. All the key features were outlined to suit the understanding of students' learning behavior and curriculum content.

During the System and Technical phase, a detailed technical plan was conducted to prepare for the development of the IMAPS application. Unity was selected as the game engine due to its flexibility, intuitive interface, and robust support for 2D educational game development. The system specifications were carefully reviewed to ensure that the application can run effectively on the hardware. IMAPS is developed using the C# coding language as it can help to develop the game's most essential functionalities. Cross-platform was also planned to ensure that the game could run and operate consistently across all devices without the risk of compatibility issues and could establish a strong foundation for development.

In the design phase, design decisions are required to initiate the development of the IMAPS application. Unity was chosen as the game engine due to its flexibility and robust support for designing 2D games. The development and design were done using only one device to ensure that a similar result of progress and perfected design can be achieved. The design process also focuses on structuring the user interface, menu navigation, and in-game interactions. The goal was to create a user experience that is simple, accessible, and engaging for Year 3 pupils. Fig. 2 shows the sample scene in IMAPS.

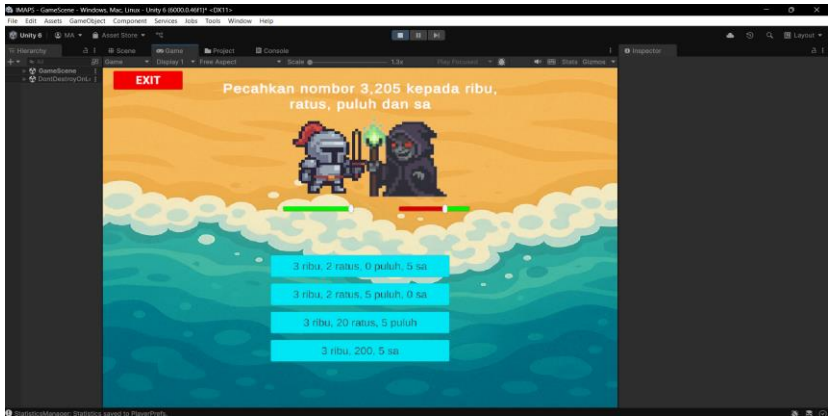

Fig. 2 *Sample of scene in IMAPS*

The Development phase involved constructing the complete IMAPS application based on the requirements and design finalised in an earlier stage of the Waterfall methodology. All core features of the game were developed in a structured, sequential manner using Unity and the C# coding language as the scripter. The coding tasks were done using only one device, and each module was completed and tested before proceeding to the next module.

The Testing phase was the final and crucial phase to ensure the quality and the effectiveness of the game. The testing was conducted in a simple and accessible environment. Unity's built-in testing and debugging tools were utilised, including WebGL browser-based simulations to ensure the application's reliability and performance. The location where the test was conducted is in a real school environment at SK Seri Bali, located in Chaah, Segamat, Johor as shown in Fig. 3. The user group consisted of Year 3 pupils from Class 3 Wira.

Fig. 3 *Testing environment with students from SK Seri Bali*

Although the web-based version of the IMAPS application remains undeployed due to the lack of an assigned hosting domain, a plan to deploy the application online was made for the future to allow broader access and use in real classroom settings. Following deployment, ongoing maintenance will be key to ensuring the application remains reliable, bug-free, and responsive to user feedback and educational developments.

In conclusion, the Waterfall methodology guided the development of the Interactive Math Adventures for Primary Students (IMAPS) through clearly defined and structured phases. From initial planning and design to development and final testing, each stage contributed to delivering an organized and well-documented educational tool.

3. Results and Analysis

This section presents the performance evaluation of the IMAPS system, integrating results from unit testing, classroom trials, pre-test surveys, and user feedback. Unit testing verified each module such as login, score tracking, question validation, and animation functioned correctly, while integration testing confirmed that these components worked cohesively. The classroom trial at SK Seri Bali involved Year 3 pupils using laptops and tablets and demonstrated the system's stability and compatibility across devices. Most students navigated the game independently and received positive feedback from both students and teachers, particularly appreciating the interactive battle mechanic.

To better understand the learning preferences, experiences, and challenges faced by Year 3 students in mathematics, a pre-test survey was conducted at SK Seri Bali. This questionnaire aimed to gather baseline data on student attitudes towards mathematics, preferred learning methods, prior exposure to educational tools, and common learning challenges. The results revealed that most students favored direct teacher instruction but also enjoyed math games. Forgetfulness and difficulty understanding questions were the main learning barriers, and many students had never used digital tools in their math learning. These findings were used to inform the development of IMAPS by focusing on user-friendly visuals, game-based reinforcement, and interactivity.

Table 1 *Summary of Student Responses to Mathematics Learning Questionnaire (IMAPS Pre-Test)*

Question	Answer Choice	Number Of Response
What is your gender?	Male	21
	Female	9
Which learning method helps you enjoy learning Mathematics?	Playing games	4
	Watching the teacher teach	11
	Doing exercises in a book	5
	Watching videos	0
Has your teacher ever used game in your mathematics class?	Yes	20
	Not sure	4
	Never	6
Do you enjoy playing math games?	Yes, it's very fun!	17
	Sometimes	13
	Don't like it	0
Have you ever used this tool while learning Mathematics?	Calculator	0
	Computer / Tablet	7
	Number blocks / beads	2
	Number cards	0
	Have never used	21
What makes Mathematics difficult for you?	Don’t understand the question	10
	Afraid of making mistakes	2
	The calculations are too difficult	0
	Forget quickly	17

Based on Table 1, most students were male and reported a positive or neutral interest in mathematics. Direct teacher instruction was the most favored learning method, followed by workbook exercises and games. A significant number of students had previously encountered games in class and enjoyed using them, with none reporting dislike for math games. Despite this, over two-thirds had never used digital tools like tablets or calculators for math learning.

The most common challenges included forgetfulness and not understanding questions, which supports the use of IMAPS features such as animated feedback, repeated practice, and simple language. The lack of exposure to digital tools also highlights the importance and relevance of introducing gamified educational platforms like IMAPS into classrooms.

The data reveals that while traditional teaching remains dominant, students are eager to engage with interactive and game-based methods. IMAPS is aligned with these preferences and addresses key learning challenges through its design. The system shows strong potential to improve mathematics learning experiences, although future updates should consider adding persistent progress tracking and adaptive difficulty features to further personalize learning outcomes.

Following the classroom implementation, a post-testing session was conducted with Year 3 pupils from Class 3 Wira at SK Seri Bali to evaluate their experience using IMAPS. Based on Table 2, verbal responses and teacher observations revealed that most students found the game enjoyable, particularly appreciating the adventure-style knight-versus-monster battles that encouraged active participation. Students expressed feelings more motivated to practice mathematics through the game compared to traditional worksheets. Teachers echoed this sentiment, noting higher levels of focus and enthusiasm among pupils. While some students found certain levels slightly challenging, they did not encounter any technical issues or interface difficulties. The

positive post-test feedback confirmed that IMAPS was effective, user-friendly, and age appropriate. This final evaluation supports the game's value as a gamified learning tool and highlights its potential for wider classroom adoption.

Table 2 *Post-Testing Interview Responses from Year 3 Students on IMAPS Experience*

Question	Student 1	Student 2	Student 3	Student 4	Student 5
1. What was your first impression of the IMAPS	It was exciting.	It was fun.	It was interesting.	I was excited.	It felt exciting.
2. Was the game easy to use and understand?	Yes, it was easy to use and Understand.	Yes, it was way easier than I expected.	It was a bit easy.	It was easy to navigate.	It was easy to use.
3.Would you like to use IMAPS again in the	I would like to use IMAPS again.	I would love to use it once again.	Yes, I would like to try again.	I would like to play this game.	Yes. I would like to try again.
4.Does maths feel easier after using	Yes absolutely.	It feels easy.	It's a little bit easier.	It feels easier now.	No. Math still feels hard for me.

The evaluation of IMAPS through pre-testing, classroom trials, and post-testing feedback indicates that the system effectively supports mathematics learning for primary students. It successfully engages learners through its adventure-based gameplay, animated feedback, and curriculum-aligned content. The positive responses from both students and teachers confirm that IMAPS enhances motivation, encourages practice, and offers a fun alternative to traditional worksheets. While some improvements are needed such as adaptive difficulty and progress tracking the overall findings suggest that IMAPS has strong potential for wider implementation in educational settings.

4. Conclusion

IMAPS demonstrates the potential of gamified learning to enhance mathematics education among primary school pupils. By integrating adventure-based gameplay with interactive challenges, the platform successfully increased student motivation and engagement. The use of the Waterfall methodology provided a clear and structured development process; however, it also introduced limitations in adaptability, particularly when addressing evolving user needs and feedback. With further development especially in expanding content, enhancing personalization, and incorporating persistent data storage IMAPS could evolve into a more robust and inclusive educational tool. Future educational projects would benefit from greater flexibility in development and continuous involvement of users throughout the design and testing stages. Engaging both students and teachers during these phases can help ensure that the final product aligns with classroom needs and learning objectives. Overall, IMAPS lays a strong foundation for future innovation in educational game design and offers meaningful insight into the effectiveness of gamified learning for young learners.

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Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design****: Muhammad Fikri Hakim Adnan, Muhammad Haziq Hakim Azreen;* ***data collection****: Pavan Vikram Vikraman;* ***analysis and interpretation of results****: Muhammad Fikri Hakim Adnan, Pavan Vikram Vikraman, Muhammad Haziq Hakim Azreen;* ***draft manuscript preparation****: Muhammad Fikri Hakim Adnan, Pavan Vikram Vikraman, Muhammad Haziq Hakim Azreen. All authors reviewed the results and approved the final version of the manuscript.*

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