JOURNAL OF DIGITAL SYSTEM DEVELOPMENT

https://e-journal.uum.edu.my/index.php/jdsd

How to cite this article:
Norshahimi, A.S., Maharoof, I.S.M. & Salam, S.N.A. (2024). MyMathly: A Persuasive Mobile Game Application in Enhancing Mathematics Learning for School Learners. *Journal of Digital System Developments, 2*(2), 93-107. https://doi.org/10.32890/jdsd2024.2.2.7

MYMATHLY: A PERSUASIVE MOBILE GAME APPLICATION IN ENHANCING MATHEMATICS LEARNING FOR SCHOOL LEARNERS

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Received: 28/07/2024 Revised: 07/09/2024 Accepted: 26/09/2024 Published: 20/10/2024

ABSTRACT

The growing reliance on technological devices among children, mainly through mobile games, poses risks such as addiction while also offering opportunities for educational enhancement. In Malaysia, only 36% of primary school students achieve excellence in mathematics, a situation worsened by negative attitudes and anxiety towards the subject. Traditional teaching methods have proven inadequate in addressing these challenges. To tackle this issue, MyMathly, a gamified persuasive mobile game prototype, is developed to motivate students and improve their proficiency in mathematics. A pilot study has been conducted to evaluate the persuasiveness and effectiveness of the MyMathly prototype using the Computer System Usability Questionnaire (CSUQ) as an instrument. It has been evaluated across four key elements: ease of use, ease of learning, information structure, and user satisfaction. The findings indicate that MyMathly successfully engages students, improves their motivation, and positively influences their behaviour towards learning mathematics. This study contributes valuable insights into designing and implementing gamified educational tools that align with the Malaysian curriculum, addressing cultural relevance and educational needs.

Keywords: MyMathly, gamified mobile application, primary school learners, persuasive strategies

INTRODUCTION

The younger generation is a vital component of society, representing a country's most valuable asset and the driving force behind its future development. The Alpha Generation, or Gen-A, born between 2010 and 2024, is anticipated to significantly emphasise high-tech living and material possessions influenced by preceding generations (McCrindle et al., 2021). The advent of technological devices as toys has led this generation to perceive life through smartphones, tablets, and the internet (Fadzil et al., 2016). The popularity of mobile devices among children aged 4-14 has been rising since 2005, proving effective in developing language and problem-solving skills and increasing interest in learning (Kokkalia & Drigas, 2016). Hence, mobile learning has emerged as an effective method of education both inside and outside the classroom.

Convincing or influencing another person's beliefs, attitudes, motivations, or behaviour through effective communication is commonly referred to as persuasion (Oinas-Kukkonen & Harjumaa, 2018). Persuasion in mobile technology can help people change their habits or improve their abilities by monitoring their behaviour (Almonani et al., 2014). Persuasive technology is a powerful tool for educators, who may use it to positively affect the attitudes and actions of their students (Mintz & Aagaard, 2012). One of the technologies for persuasion that were recognised is learning through gamification.

The current state of mathematics education in primary schools in Malaysia is concerning, with only 36% of students achieving excellent results (Lembaga Peperiksaan Malaysia, 2019). This issue is compounded by negative attitudes and biases towards mathematics, which contribute to a lack of motivation and increased anxiety among students (Deringöl, 2018). Traditional teaching methods have proven inadequate in addressing these challenges, as they often fail to engage students in a way that fosters a positive learning environment (Lim & Toh, 2022).

Additionally, the rising use of mobile devices among children presents risks and opportunities. At the same time, addiction has potential, and well-designed educational apps can leverage this trend to enhance learning (Serra et al., 2021). Given these challenges, there is a critical need for innovative solutions that align with the Malaysian curriculum and effectively engage and motivate students. The purpose of this study is to design, develop and validate the effectiveness of MyMathly, a gamified persuasive mobile application specifically designed to enhance mathematics learning among Malaysian primary school students, by assessing its usability, engagement, and alignment with the national curriculum where this paper is organised as follows: The Literature Review discusses persuasive technology and gamification in education. The Methodology explains the development and evaluation of MyMathly using the ADDIE model. The Findings and Discussion present the pilot study results, and the conclusion summarises critical insights and future research directions.

LITERATURE REVIEW

This section examines vital concepts of persuasive technology in education and its impact on learning behaviours. It also explores the use of gamification to enhance student engagement and motivation. Finally, it provides a comparative analysis of existing mathematics learning applications, highlighting gaps that

MyMathly addresses.

Introducing persuasive technology tailored to the behavioural and motivational characteristics of the target audience is essential for enhancing mathematics skills and fostering positive attitudes toward the subject. Consequently, MyMathly, a gamified persuasive mobile technology, has been developed to motivate students to improve their mathematics skills and increase their proficiency in the subject.

Using mobile apps with gamification elements engages students by encouraging active participation in educational games. A comparative analysis of existing apps shows that persuasive technology, which strategically influences user behaviour (Fogg, 2002), has gained attention in education. Its application, mainly through gamification, enhances student engagement and motivation by incorporating game elements into learning activities (Mintz & Aagaard, 2012).

Challenges in Mathematics Education in Malaysia

The state of mathematics education in Malaysia is concerning, with only 36% of primary students achieving excellent results (Lembaga Peperiksaan Malaysia, 2019). Although the failure rate in SPM Mathematics slightly improved from 24.3% in 2022 to 23.2% in 2023, it remains the subject with the highest failure rate (Kementerian Pendidikan Malaysia, 2024). Negative attitudes toward math decrease motivation and anxiety (Deringöl, 2018). The shift to online learning during the COVID-19 pandemic increased mobile device use, raising concerns about game addiction affecting learning motivation (Serra et al., 2021). Digital education can help address these issues.

Existing Mathematics Learning Applications with Game-Based and Persuasive Elements

Several mobile applications have been developed that incorporate gamification to teach mathematics. Using mobile apps with gamification elements for learning is considered a method to engage students' curiosity in exploring new topics and is focused on student's active participation in educational games. A comparative analysis has been conducted to explore the range of existing mobile apps developed for this purpose.

Table 1

Comparative analysis of existing mathematics applications

Applications	Features	Persuasive Strategies
Mathsol (Anwar et al., 2020)	Apply gamification elements to teach basic numerals to students.	Rewards, Tunneling, Reduction, Tailoring
Roomad (Annamalai et al., 2022)	Implement game-based elements with a detailed storyline for year 4 Malaysian students.	Rewards, Tunneling, Attractiveness, Reduction, Tailoring
Sifir Run (Ishak & Rahman, 2021)	Implement game-based elements to teach basic multiplication.	Tunneling, Attractiveness, Reduction, Tailoring

P-JMat (Ramli et al., 2020)	Implement game-based elements to teach multiplication and division to year three students.	Self-monitoring, Reduction
Forest Multiplication (Ali et al., 2021)	Apply game-based elements to teach multiplication to primary school students.	Attractiveness
Beem Math X & Bingo Math X (Widodo et al., 2018)	Use gamification elements to teach basic arithmetic operations to elementary school students.	Conditioning, Rewards, Praise
The Basic Numbers (Vobornik, 2019)	Implement gamification elements to teach basic mathematics to year one students.	Reduction, Self-Monitoring

The comparison of mathematics learning apps, such as Mathsol, Sifir Run, P-JMat, and The Basic Numbers, highlights the use of various persuasive strategies. However, these strategies are applied separately, revealing a gap in using all eight persuasive strategies in mobile math games for Malaysian primary students. Additionally, apps like Roomad and P-JMat are limited to specific grade levels, and many, including Mathsol and Sifir Run, are not aligned with the Malaysian syllabus, reducing their relevance and effectiveness (Kementerian Pendidikan Malaysia, 2024).

MyMathly was developed to apply persuasive strategies tailored to the Malaysian context and aligned with the national syllabus to address these issues. This ensures the app is engaging and relevant for Year 1–3 students, aiming to improve engagement, completion rates, and math proficiency. The lack of alignment with the Malaysian syllabus in apps like Mathsol and The Basic Numbers undermines their potential. MyMathly fills this gap by integrating strategies like tunnelling, self-monitoring, and positive reinforcement to meet local learning needs and address motivational challenges (Fogg, 2002; Mintz & Aagaard, 2012). In conclusion, while gamification has been widely studied, there is a need for educational tools that are culturally relevant. This study evaluates MyMathly, a gamified app designed to enhance math learning for Malaysian primary students, contributing insights into the effectiveness of gamified educational tools.

Persuasion can be achieved through numerous persuasive technology strategies intended to encourage desired behaviours or attitudes, which can be integrated into the design of gamification apps. Fogg (2002) developed 16 persuasive strategies for influencing behaviours. These persuasive strategies used in applications are often integrated and applied in various combinations to achieve the desired effect (Harjumaa et al., 2009). Tailoring persuasive methods to specific groups or behaviours can enhance user engagement by allowing for a more personalised approach to encouraging desired behaviours or attitudes. MyMathly is developed using eight persuasive strategies derived from Fogg's proposed strategies. The list of persuasive strategies includes tunnelling, tailoring, reduction, conditioning, self-monitoring, praise, rewards, and attractiveness.

Tunnelling

Tunnelling is a strategy of utilising technology to lead people through a process or experience to persuade them to change their behaviour or attitude (Fogg, 2002). One commonly employed method of tunnelling in an education setting involves directing students through a course by providing them with a table of contents, structural map, or flowchart that illustrates the layout of modules or multiple levels (Krishnamoorthy & Merchant, 2023). In addition, tunnelling can be implemented by offering students a predetermined lesson while allowing them to choose their lesson (Trân, 2008).

Tailoring

This strategy suggests that persuasive technology is more effective when the information presented to the individual is tailored to their specific needs, interests, personality traits, and utilisation context (Fogg, 2002). Tailoring is possible through interactive scenario-based learning resources and personalised messages that enable students to engage with the content relevant to their needs and interests (Mintz & Aagaard, 2012). Furthermore, providing students with different content medium options, such as videos and written materials, can increase their motivation and engagement with the material.

Reduction

Reduction is a strategy that simplifies complex behaviours into basic tasks by reducing cognitive burden and effort to increase users' probability of performing the behaviour (Fogg, 2002). Adopting simplified instructional materials to match students' cognitive abilities and learning needs can be beneficial, particularly for those who struggle with complex tasks (Trân, 2008). Additionally, employing multiple learning paths tailored to individual goals reinforces the application of reduction (Krishnamoorthy & Merchant, 2023). This highlights the significance of offering simpler and personalised learning experiences that can result in enhanced learning outcomes.

Conditioning

The strategy suggests that persuasive technology can encourage positive behaviour through positive reinforcement until it becomes natural and habitual (Fogg, 2002). Positive reinforcement in educational apps can motivate students by providing immediate positive feedback and other incentives, such as enhancing fact recall through assessments, illustrating concepts, applying explanations, and following procedures (Lim & Toh, 2022). By providing a rewarding learning experience, conditioning can help shape behaviours and develop good habits.

Self-Monitoring

Self-monitoring assists individuals in assessing their progress or status in accomplishing their goals (Fogg, 2002). Some standard methods in applying this strategy to the educational environment are incorporating progress bars, providing notifications on completion levels, and offering test analytics to help learners track their progress toward their goals (Krishnamoorthy & Merchant, 2023). This approach empowers students to take responsibility for their learning and supplies them with the tools to stay on track and attain results.

Praise

This strategy is applied by giving feedback on users' behaviours through words, sounds, or images, which can influence users to be more receptive to persuasion (Fogg, 2002). When taking small steps towards behaviour change, encouragement through praise is effective in increasing students' confidence in their ability to achieve the desired behaviour (Oyebode et al., 2021).

Rewards

This strategy states that providing virtual rewards to users who perform the desired behaviour can help motivate and reinforce that behaviour (Fogg, 2002). Virtual rewards are popular in gamified education apps where users are rewarded for completing tasks or reaching milestones. Rewards can effectively keep students engaged and motivated as they experience a sense of accomplishment (Orji et al., 2018).

Attractiveness

Attractiveness refers to technology designed with aesthetically pleasing elements and is more likely to be effective in persuading target users, which can increase user engagement and motivation (Fogg, 2002). Apps with an appealing visual design have a greater chance of capturing the attention and interest of primary school children than those without such design elements (Javora et al., 2019).

These eight selected strategies are not inherently more significant than others, nor do they represent all possible strategies. Nonetheless, based on the existing literature stated by Krishnamoorthy & Merchant (2023), Mintz and Aagaard (2012) and Trân (2008), these persuasive strategies are the most frequently used in educational settings. Thus, they were chosen for this study.

MYMATHLY GAME ELEMENTS

MyMathly is a gamified mobile app that supports Malaysian primary school students (ages 7 to 9) in learning fundamental mathematics concepts. It incorporates vital gamified elements such as story, characters, feedback, and points to enhance user engagement and motivation (Johnson et al., 2017).
The story element uses visually appealing, astronomy-inspired graphics to evoke a sense of adventure, appealing to children's curiosity and imagination. This emotional connection enhances the learning experience by engaging cognitive and emotional responses, guiding users toward desired behaviours (Chen, 2022).

The character element features an animated astronaut, which represents the user within the game environment. This character fosters a sense of immersion, allowing users to feel more connected to the learning process (Ryan et al., 2006). Using animations links complex digital concepts to real-world applications, enhancing understanding and motivation (Mulcahy et al., 2020; Chen, 2022).

Feedback is essential to the app, providing instant responses after each completed task. This immediate feedback reinforces user satisfaction, competence, and autonomy, encouraging students to continue progressing through increasingly challenging math concepts (Fu et al., 2019; Mulcahy et al., 2020). The progress tracking feature also helps users monitor their achievements, motivating them to advance through the lessons.

The points and rewards system offers positive reinforcement by allowing students to earn points for completing levels, fostering a sense of accomplishment and promoting positive emotions (Chen, 2022). This system educates students about the connection between actions and outcomes, helping to maintain motivation and engagement throughout the learning process (Orji et al., 2014; Senbel et al., 2014).

METHODOLOGY

The development of the MyMathly high-fidelity prototype is adapted based on the five phases of the ADDIE model (Drljaca et al., 2017). The model was selected because it provides a clear and systematic process for creating an excellent educational mobile game design.

Analysis

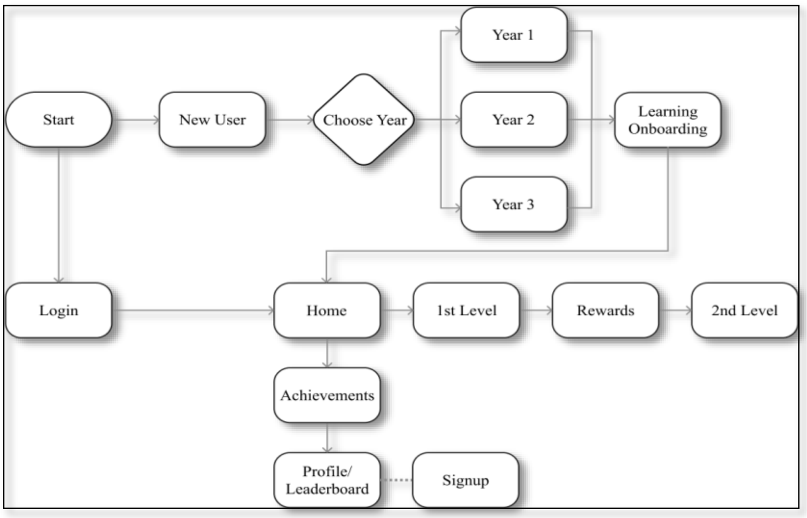
In the analysis phase, relevant literature is reviewed to identify the current issue related to the topic that necessitates the development of persuasive technology as a solution. The goal is to determine the challenges primary students face in getting motivated when learning mathematics and to identify how persuasive technology and relevant strategies can be used to resolve these challenges.

Design

The design phase consists of two parts: the development of learning materials and the application design. The first part entails the creation of learning materials and assessment techniques for the application, which was derived from mathematics textbooks and exercise books for years 1 – 3 (Lean et al., 2022) (Lean & Maun, 2022) and (Puteh et al., 2022). By incorporating the findings from the analysis phase, appropriate persuasive strategies were chosen to include in the application. Then, a flowchart is created to provide a comprehensive overview of the application's learning concept, persuasive strategies, and user flow. Figure 1 below indicates the flowchart for MyMathly. Finally, a low-fidelity wireframe is constructed to provide a high-level visual representation of the persuasive strategies implemented in the app.

Figure 1

MyMathly Flowchart



The app is designed with a tailored onboarding process to delay the account creation process, which can be beneficial in increasing users' intention to use the app, as it allows for user personalisation and the opportunity to make small commitments before deciding to create an account (Terres et al., 2020) Here, MyMathly uses tailoring to provide personalised learning content that is suited to each user's level of understanding. During the onboarding phase, the app asks a set of onboarding mathematics questions to determine the student's current knowledge. Then it provides a suitable learning path for the users to start learning.

The design of MyMathly incorporated tunnelling as one of its persuasive strategies, which involves guiding users through learning content one question at a time. This approach is intended to help users focus on each of the questions displayed and avoid feeling overwhelmed by the content volume. Limiting the number of questions per level to five is a reduction strategy to encourage students to level up and develop a learning habit within the MyMathly app. The self-monitoring strategy in MyMathly helps students monitor their progress through various features, such as levelling up and viewing their achievements. By providing users with a clear overview of their progress, this strategy helps to increase motivation and engagement with the app.

Conditioning is utilised in MyMathly by providing positive reinforcements through words of encouragement while answering questions to motivate users to continue learning through the app. In addition, praise is given through positive affirmations to motivate and encourage users each time they answer a question accurately. This positive reinforcement strategy helps to build self-confidence and promote a positive learning experience for the user.

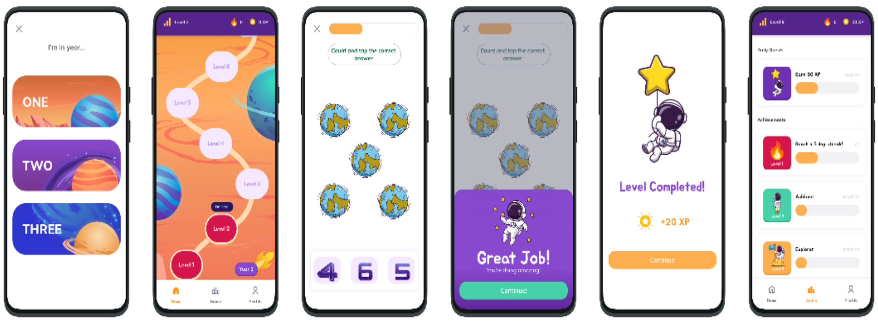
MyMathly employs the rewards by giving points to students every time they complete a set of questions to level up. These points can be collected to unlock achievements, which provides additional incentives for users to achieve their goals and keep using the app. This strategy encourages students to interact with the application more frequently and extensively. Finally, MyMathly utilises attractiveness by incorporating visually appealing graphics inspired by astronomy, an astronaut character, and bright colours to make the learning experience more enjoyable for young students.

Development

After the confirmation of the low-fidelity wireframe, phase three involves the development of the high-fidelity prototype. MyMathly is developed using the Figma prototyping software. During the development of the prototype, the visual elements, including typography, colour palette, iconography, illustrations, and characters, were incorporated into the designs to create a unified and aesthetically pleasing interface. Figure 2 below illustrates the screenshots of the MyMathly app.

Figure 2

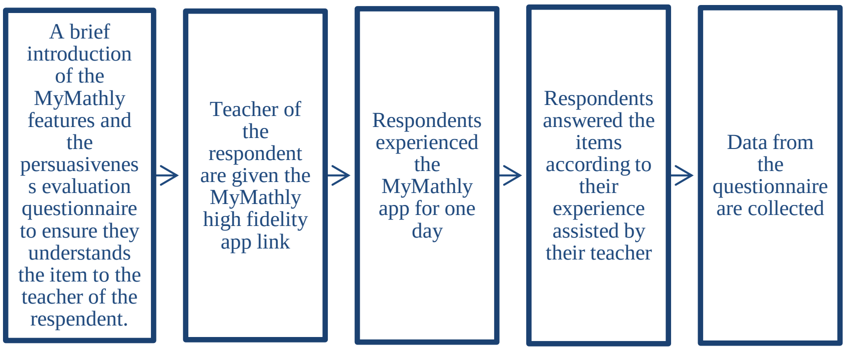
Screenshots of the MyMathly App



Evaluation

Figure 3

Process of collecting data for a pilot study



This section reports the findings of evaluating the persuasiveness of MyMathly, a mobile game-based learning application related to mathematics. The pilot study was conducted where the selection process involved randomly choosing six students from SK Bandar Laguna Merbok, with two students selected from each of the Year 1, Year 2, and Year 3 cohorts. This random sampling approach is employed to ensure a diverse representation of student abilities and experiences with mathematics, allowing the study to capture a broad perspective on the effectiveness of the MyMathly app across different levels of primary education.

A total number of six respondents was made due to the pilot nature of the study, which focused on gathering in-depth qualitative insights into the usability and persuasiveness of the MyMathly app. This smaller sample size allowed for detailed observations and personalised interactions, critical in identifying and addressing usability issues. Additionally, resource constraints and the need for rapid iterative development made a smaller sample both practical and effective for this research phase. Future studies will expand on these findings with a larger sample size to validate the app's effectiveness across a broader population.

For the MyMathly persuasiveness evaluation, five elements of persuasiveness were examined: ease of use, ease of learning, information structure and design, and user satisfaction with the app. As an assessment tool, the researchers used a CSUQ (Computer et al.) by Lewis (1995) instruments to evaluate the persuasiveness of the application. The CSUQ (Computer et al.) is selected for this study due to its established reliability and validity in assessing the usability of interactive systems. Given that MyMathly is a gamified mobile application, the CSUQ is particularly relevant for evaluating key aspects such as ease of use, learning, information structure, and user satisfaction. These metrics are crucial in understanding how effectively the app engages students and supports their learning process. This survey has twenty questions, and respondents are requested to rate their responses on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

The close relationship between user satisfaction and the effectiveness of persuasive strategies in mobile applications justifies the use of the CSUQ in this study. While CSUQ primarily measures usability aspects such as ease of use, ease of learning, and information structure, these factors are integral to the success of persuasive technologies. A positive user experience, as reflected in high CSUQ scores, indicates that the app's persuasive elements or strategies effectively motivate and engage users, thereby achieving the desired behaviour changes (Fogg, 2002; Mintz & Aagaard, 2012).

During the data collection process, the respondents were given a quick overview of the MyMathly features and instructions on using the app. Then, the respondents experienced MyMathly individually for one day to play the app and learn the learning content throughout the app. After the session, the respondents were told how to fill out the persuasiveness evaluation so that they would know what to do. The interviewees answered the questions based on what they knew. Figure 3 indicates how the process of collecting data.

FINDINGS AND DISCUSSION

Table 2

Respondent's perspectives on the persuasiveness of MyMathly app

	1*	2*	3*	4*	5*	Mean	Overall Mean
Ease of use							
It is simple to use this application					6	5.00	
It is easy to learn mathematics through this application.					6	5.00	
The information provided by the application and how to use it is clear.				1	5	4.83	4.95
It is easy to find the information I needed					6	5.00	
Ease of Learning							
I can effectively complete my task by applying this application					6	5.00	
I can complete my tasks quickly using this application.				1	5	4.83	
I can efficiently complete my task by applying this application.				2	4	4.67	
The application provides me with guidance on learning mathematics better.					6	5.00	4.92
Whenever I make a mistake using the application, I quickly recover.					6	5.00	
The information provided for the application is easy to understand					6	5.00	
The information is effective in helping me complete the mathematics tasks.					6	5.00	
Information Structure and Design							
The organisation of information on the application screens is clear					6	5.00	
The interface of this application is pleasant.					6	5.00	5.00
This application has all the functions and capabilities I expect it to have					6	5.00	

Satisfaction				
Overall, I am satisfied with how easy it is to use this application	2	4	4.67	4.93
I became productive quickly applying this application.		6	5.00	
I feel happy when using this application.		6	5.00	
I am enthusiastic when using this application.		6	5.00	
I wish there were more applications like this for me to learn.		6	5.00	

* Number of respondents
Likert scale - 1:Strongly Disagree, 2:Disagree, 3:Natural, 4:Agree, 5:Strongly Agree

Table 2 above shows the statistical study of the expression of the respondents' beliefs about the persuasiveness of MyMathly. The descriptive analysis of the collected data showed that all of the usability aspects were given an overall mean score higher than 4.50.

This means that all students agree that the MyMathly application is good in terms of how easy it is to use, how easy it is to learn, how the information is structured and designed, and how satisfied they are with it. The assessments for the ease-of-use design look at how easy it is to use, how user-friendly it is, how well it works every time, and how often it doesn't work as expected. The average for this section as an entire is 4.95. Ease of learning is how quickly a user who has never seen the user interface before can do basic tasks. This construct has a total mean of 4.92.

The students were judged on how well they should use multimedia technology and colours in the information structure and design tasks. On average, they got a score of 5.00, which is the maximum value for the element. The last thing examined is satisfaction, which includes how fun it is to learn, how attractive it is to be used for educational goals, and how fun it is to learn. This whole thing gets a mean score of 4.93.

The findings indicate that MyMathly is a persuasive application characterised by user-friendliness, ease of use, and ease of learning, successfully meeting the satisfaction of its target users—Year 1, Year 2, and Year 3 primary school students. Most respondents expressed satisfaction and motivation to use this application. This positive reception is attributed to MyMathly's implementation of gamification in learning, which creates a more interactive learning environment aligned with the latest technological advancements.

MyMathly employs simple and easily comprehensible language for its target user group, significantly contributing to the application's ease of use. Consequently, users find it straightforward to understand the language used, as evidenced by most respondents indicating that MyMathly is "very easy" to use in the questionnaire.

Most respondents indicated that MyMathly is easy to learn and use. They reported efficiently completing tasks within the application and finding the provided information straightforward and comprehensible. This ease of use has enhanced the application's persuasiveness by increasing user motivation and encouraging behaviour change towards more frequent use of MyMathly to strengthen mathematics learning.

Additionally, the information structure and design of the application received very positive feedback from respondents. The clear, simple, and clean information layout on each page contributed to this positive feedback. This clarity has further increased the persuasive element of MyMathly, boosting users' confidence in the application.

The respondents in the pilot study expressed high satisfaction with using MyMathly. They expressed a desire for more applications like it to foster a more interactive learning experience among primary school students. This feedback demonstrates that MyMathly is expected to effectively incorporate persuasive elements that can shape user behaviour in a large scale of user evaluation.

CONCLUSION

In conclusion, this study plays a crucial role in designing, developing, and assessing the persuasiveness of MyMathly as a learning application. The findings demonstrate that MyMathly effectively enhances motivation, engagement, and comprehension through gamification, encouraging students to study more diligently.

However, the study has limitations. The small sample size restricts the generalizability of the results, and the short study duration may not capture long-term effects. Future research should involve a more extensive and diverse sample and examine long-term outcomes and the app's adaptability across different age groups. Therefore, future development of learning applications should increasingly incorporate game-based learning and gamification concepts to captivate the interest of future generations and align with the school curriculum.

ACKNOWLEDGMENT

We want to express our special thanks to SK Bandar Laguna Merbok for their assistance in facilitating this study and to the teachers and students who participated in the pilot study. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

REFERENCES

Ali, M. H. M., Jasmi, N. I. N., Khalip, N. A., Hamdi, H. N., Jofri, M. H., Mohamed, J., & Hamid, M. A. (2021). Forest Multiplication: A Game-Based Learning Apps to Enhance Learning Experience in Multiplications for Primary Students towards 21st Century Learning Skills. *Multidisciplinary Applied Research and Innovation*, *2*(1), 189-199.

Almonani, E., Husain, W., San, O. Y., Almomani, A., & Al-Betar, M. (2014). Mobile game approach to prevent childhood obesity using persuasive technology. In *2014 International Conference on Computer and Information Sciences (ICCOINS)* (pp. 1-5). IEEE.

Annamalai, S., Che Omar, A., & Abdul Salam, S. N. (2022). Rory's Mathematics Adventure's (ROMAAD) Mobile Game-Based Learning Application: An Usability Evaluation. *International Journal of Education, Psychology and Counseling*, 7 (48), 575-585.

Anwar, N., Kristiadi, D. P., Novezar, F. A., Tanto, P. A., Septha, K., Ardhia, P., ... & Abraham, J. (2020). They are learning math through mobile games for primary school students. *Sylwan*, *164*(5), 346-352.

Atighi Lorestani, E., & Khalili, M. (2017). How lighting dynamics create social interactive games. In *DS 88: Proceedings of the 19th International Conference on Engineering and Product Design Education (E&PDE17), Building Community: Design Education for a Sustainable Future, Oslo, Norway, 7 & 8 September 2017* (pp. 680-685).

C. Y. Lean, and R. Maun (2022). *Buku Teks Matematik Tahun 2 (Jilid 1)*. Dewan Bahasa dan Pustaka Kuala Lumpur.

C. Y. Lean, W. Y. W. Ngah, and G. Krishnan (2022). *Buku Teks Matematik Tahun 1 (Jilid 1)*. Dewan Bahasa dan Pustaka Kuala Lumpur.

Chen, K. (2022). An Interactive Design Framework for Children's Apps for Enhancing Emotional Experience. *Interacting with computers*, *34*(3), 85–98.

Deringöl, Y. (2018). Primary school students' mathematics motivation and anxieties. *Kıbrıslı Eğitim Bilimleri Dergisi*, *13*(4), 537-548.

Dorouka, P., Papadakis, S., & Kalogiannakis, M. (2021). Nanotechnology and mobile learning: perspectives and opportunities in young children's education. *International Journal of Technology Enhanced Learning*, *13*(3), 237-252.

Drljaca, Dalibor & Latinović, Branko & Stankovic, Zeljko & Cvetković, Dragan. (2017). ADDIE model for the development of e-courses. 10.15308/Sinteza-2017-242-247.

Fadzil, N. M., Abdullah, M. Y., & Salleh, M. A. M. (2016). The level of tolerance for parents sanctioning children's use of gadgets leads to nomophobia: early-age gadget exposure. *International Journal of Arts & Sciences*, 9(2), 615.

Fogg, B. J. (2002). Persuasive technology: using computers to change what we think and *do—ubiquity*, *2002*(December), p. 2.

Fu, F. L., Su, R. C., & Yu, S. C. (2009). EGameFlow: A scale to measure learners' enjoyment of e-learning games. *Computers & Education*, 52(1), 101-112.

Gómez-García, G., Marín-Marín, J. A., Romero-Rodríguez, J. M., Ramos Navas-Parejo, M., & Rodríguez Jiménez, C. (2020). Effect of the flipped classroom and gamification methods in developing a didactic unit on healthy habits and diet in primary education. *Nutrients*, *12*(8), 2210.

Harjumaa, M., Segerståhl, K., & Oinas-Kukkonen, H. (2009). Understanding persuasive software functionality in practice: a field trial of polar FT60. In *Proceedings of the 4th International Conference on Persuasive Technology* (pp. 1-9).

Ishak, A. M., & Rahman, M. H. A. (2021). Pembangunan Permainan Mudah Alih Matematik'Sifir Run'untuk Pembelajaran Topik Darab bagi Murid Sekolah Rendah. *Journal of Engineering, Technology, and Applied Science*, *3*(3), 114-127.

Javora, O., Hannemann, T., Stárková, T., Volná, K., & Brom, C. (2019). Children like it but do not learn more: Effects of esthetic visual design in educational games. *British Journal of Educational Technology*, *50*(4), 1942-1960.

Johnson, D., Horton, E., Mulcahy, R., & Foth, M. (2017). Gamification and serious games within domestic energy consumption: A systematic review. *Renewable and Sustainable Energy Reviews*, pp. 73, 249–264.

Kementerian Pendidikan Malaysia (2024). Laporan Analisis keputusan peperiksaan SPM Tahun 2023. http://lp.moe.gov.my/files/spm/2024/Laporan%20Analisis%20Keputusan%20SPM%202023.pdf

Kokkalia, G. K., & Drigas, A. S. (2016). Mobile learning for special preschool education. *International journal of interactive mobile technologies*, *10*(1).

Krishnamoorthy, L., & Merchant, Z. (2023). Applying Persuasive Techniques in an Online Learning Environment: A Mixed-Method Study. *Pedagogical Research*, *8*(2).

Kuo, M. J. (2007). How does an online game-based learning environment promote students' intrinsic motivation for learning natural science, and how does it affect their learning outcomes? In *2007, First IEEE International Workshop on Digital Game and Intelligent Toy Enhanced Learning (DIGITEL'07)* (pp. 135–142). IEEE.

Lembaga Peperiksaan Malaysia. (2019). Pelaporan Pentaksiran Sekolah Rendah 2019.

Lewis, J. R. (1995). *IBM Computer Usability Satisfaction Questionnaires: Psychometric Evaluation and Instructions for Use.* International Journal of Human-Computer Interaction, 7:1, pp. 57–78.

Lim, F. V., & Toh, W. (2022). Considerations on the curation of educational apps for digital play and learning. *Contemporary Educational Technology*, *14*(3), ep366.

M. Puteh, C. Y. Lean, and G. Krishnan (2022) *Buku Teks Matematik Tahun 3 (Jilid 1)*, vol. 135, no. 4.

McCrindle, M., Fell, A., & Buckerfield, S. (2021). *Generation Alpha: Understanding our children and helping them thrive*. Hachette Australia.

Mintz, J., & Aagaard, M. (2012). The application of persuasive technology to educational settings. *Educational Technology Research and Development*, *60*, 483-499.

Mulcahy, R., Russell-Bennett, R., & Iacobucci, D. (2020). Designing gamified apps for sustainable consumption: A field study. *Journal of Business Research*, *106*, 377-387.

Oinas-Kukkonen, H., & Harjumaa, M. (2018). Persuasive systems design: key issues, process model, and system features 1. In *Routledge Handbook of Policy Design* (pp. 87-105). Routledge.

Orji, R., Tondello, G. F., & Nacke, L. E. (2018). They are personalising persuasive strategies in gameful systems to gamification user types. In *Proceedings of the 2018 CHI conference on human factors in computing systems* (pp. 1-14).

Orji, R., Vassileva, J., & Mandryk, R. L. (2014). Modelling the efficacy of persuasive strategies for different gamer types in serious games for health. *User Modeling and User-Adapted Interaction*, *24*, 453-498.

Oyebode, O., Ndulue, C., Mulchandani, D., A. Zamil Adib, A., Alhasani, M., & Orji, R. (2021). I am tailoring persuasive and behavioural change systems based on stages of change and motivation in *the Proceedings of the 2021 CHI conference on human factors in computing systems* (pp. 1-19).

Ramli, I. S. M., Maat, S. M., & Khalid, F. (2020). Game-Based Learning: "Permainan Jangkaan Matematik (P-Jmat)" Application.

Ryan, R. M., Rigby, C. S., & Przybylski, A. (2006). The motivational pull of video games: A self-determination theory approach. *Motivation and Emotion, 30,* 344-360.

Senbel, M., Ngo, V. D., & Blair, E. (2014). Social mobilisation of climate change: University students conserving energy through multiple pathways for peer engagement. *Journal of Environmental Psychology*, *38*, 84-93.

Serra, G., Lo Scalzo, L., Giuffrè, M., Ferrara, P., & Corsello, G. (2021). Smartphone use and addiction during the coronavirus disease 2019 (COVID-19) pandemic: cohort study on 184 Italian children and adolescents. *Italian Journal of Pediatrics*, *47*(1), 150.

Terres, P., Klumpe, J., Jung, D., & Koch, O. (2020). Digital nudges for user onboarding: Turning visitors into users. 27th *European Conference on Information Systems - Information Systems for a Sharing Society, ECIS 2019*. pp. 0–16

Trân, D. (2008). Motivation and Persuasion in E-learning. *Trends in E-Learning*, p. 141.

Voborník, P. (2019). New Mobile Application for Effective Practice of Basic Numerical Operations at Primary School with Elements of Gamification And History Of Examples. In *ICERI2019 Proceedings* (pp. 6279–6287). IATED.

Wibowo, T., Triyono, A., Saleh, R. R., Habsyi, R., & Purwoko, R. Y. (2023). E-Modul Berbasis Android "Kitkat Versi 4.4" Untuk Memfasilitasi Asynchronous Learning Mahasiswa Pendidikan Matematika Di Ternate. *Kwangsan: Jurnal Teknologi Pendidikan*, *11*(1), 147-164.

Widodo, S., Rahayu, P., Adjie, N., Widodo, S. A., & Setiadi, B. R. (2018). The development of arithmetic gamification using digital dice. *Int. J. Eng. Technol, 7*(3.2), 751-755.