Asian Journal of Research in Education and Social Sciences
e-ISSN: 2682-8502 | Vol. 7, No. 2, 246-256, 2025
https://asianscholarsnetwork.com/asnet-journals
SPECIAL ISSUE: International Conference on Future and Sustainable Education (ICFSE) 2024

Mathepoly: Exploring the Impact of Gamification on Students' Motivation and Engagement in Mathematics

Tengku Alias Tengku Samsudin[1*], Mohd Nazim Mat Nawi[1], Nurhafizah Saidin[1], Hamidah Alamin[1], Bahirah Mohd Bashah[1], Muhammad Izzuddin Sidek[1]

[1] Department of Mathematics, Centre for Foundation Studies, International Islamic University Malaysia, Malaysia

*Corresponding Author: tengkualias@iium.edu.my

Received: 15 July 2024 | Accepted: 1 December 2024 | Published: 1 March 2025

DOI: https://doi.org/10.55057/ajress.2025.7.2.24

Abstract: *The declining interest of Malaysian students in Science, Technology, Engineering and Mathematics (STEM) education is alarming in preparing them for Industry Revolution 4.0. Despite efforts to enhance STEM education, students STE Mathematics subjects to be dry and unengaging, largely due to traditional teaching methods that fail to inspire curiosity and enthusiasm. For this reason, it has become necessary to develop educational strategies utilizing gamification and technology to maintain student interest. Gamification that involves adding game-like elements to classroom settings has become increasingly popular in education, especially for teaching Mathematics. Researchers have studied how gamification can boost student engagement, motivation, and learning experience. This study is to explore the impact of gamification in Mathematics education through the creation and implementation of "Mathepoly", a game inspired by the classic Monopoly but infused with mathematical concepts and technology. Incorporating Mathepoly board with QR codes linked to Quizizz platform enhances the application of technology and makes the learning experience more engaging. This study employed quantitative analysis based on questionnaire adapted from ARCS model incorporate three components of motivation; attention (A), confidence (C), and satisfaction (S). One of the ARCS components which is relevant (R) was replaced with perceived learning effects (PLE). Two components corresponding to engagement, both emotional and cognitive also included. The questionnaire includes 20 items that used a 5-point Likert scale. The results indicated that gamification through Mathepoly increase student motivation and engagement. Additionally, there are significant positive correlation between motivation and engagement. Thus, this indicates a high impact of using Mathepoly as a gaming tool for mathematics education.*

Keywords: Gamification, Technology, Mathematics, Motivation, Engagement

1. Introduction

Implementing STEM (Science, Technology, Engineering and Mathematics) education in educational institutions is seen as crucial for both individual and societal advancement. This novel approach is designed to develop students' critical thinking, effective communication, and abilities to solve problems (Sanders, 2009). It is an important framework of Industry Revolution 4.0, such as workforce transformation, advancing innovation, driving economic growth, sustainable development, global connectivity, and ethical principles. Merging all

elements in STEM into a problem-based approach related to the real-world will foster innovation and creativity in teaching and learning (Moore & Smith, 2014).
Nevertheless, STEM education encountered some challenges that somehow lead to further approaches for facing the challenges effectively. These challenges call for some collaborations from all parties, which are educators, policymakers, industry leaders and communities. Thus, promoting interest in STEM is the key for developing citizens who can make full use of science and technology resources (Vennix, den Brok, & Taconis, 2018). Research indicates a decrease in students' engagement with STEM subjects (Campbell, 2005). The Malaysia Education Blueprint is the first stage in promoting STEM education to promote interest and awareness of STEM education among the students and educators (Yassin, 2013). Considering these issues, one vital component in STEM becoming a concern, where the students find Mathematics subjects to be a dry and unengaging subject.

The weak engagement towards learning mathematics will cause low achievement in academic performance and it is an important factor to anticipate their knowledge acquisition and involvement in this subject whether to succeed or not (Singh, Granville, & Dika, 2002). An engagement of the students with academic achievement is important to assist teachers in advancing the performance of academically struggling students (Furlong & Christenson, 2008). Other than that, referring to study, the classes that are conducted as teacher-centred will cause less motivation among the students (Mekarina & Ningsih, 2017). The students presume that mathematics is a challenging subject to learn (Al Mutawah, 2015). These beliefs and ideas will give a negative influence towards society and the education system. Hence, academic researchers develop and implement new teaching approaches that hopefully will spark student interest and motivation to avoid phobia in Mathematics (Hemmings, Grootenboer, & Kay, 2011).

Gamification in education

Gamification that involves adding game-like elements to non-game settings has become increasingly popular in education. Gamification is a strategy used to increase user motivation and engagement by incorporating game features into no-gaming environments (Attali & Arieli-Attali, 2015). It can be implemented as new innovative techniques to conduct the class with students, especially those learning mathematics. Using game design ideas and elements in education systems will improve learning outcomes and inspire the students to enhance the students' engagement and meet learning objectives that is known as gamification in education. Other than that, gamification encourages ideas, strategies and resources from the game's mechanics to increase motivation and learning both formally and informally (König, 2021). Gamification in education gave information on the game effectiveness, when assessing the impact of gamified approaches on student engagement, motivation and academic performance.

Apart from the acquisition of knowledge and skills, gamification gives impacts on students' behaviour, commitment and motivation which lead to the enrichment of their knowledge and skills (Huang & Soman, 2013). The design in the game can develop and refine gamified learning environments focusing on specific educational games to optimize learning experiences. Games are continuous experiments which lead to frequent failures. In order to master the game, it requires repeated failures, with each attempt providing a valuable lesson (Jordan, 2009). Gamification in education includes comprehensive understanding of how gamified learning can influence students' attitudes towards education over long periods. This includes evaluating how gamification affects students' motivation, engagement, and overall perceptions of learning. Cooperative learning can be achieved where the students can work together in a small group, to enhance academic achievement, helping each other and improve

problem-solving abilities among the students (Güvenç & Ün Açikgöz, 2007). All group members' success is important to the success of cooperative learning groups which depends on the success of each team member within the group (Cebeci & Tekdal, 2006). Thus, gamification in education has been shown in research to improve student's motivation, engagement and learning outcomes.

Objectives

This study is to explore the impact of gamification in Mathematics education through the creation and implementation of "Mathepoly", a game inspired by the classic Monopoly but infused with mathematical concepts and technology. It is important to understand the positive correlations between motivation and engagement, and to highlight the significant and positive impact that various educational approaches, tools, or method can be use as all these innovations will enhancing the learning and teaching outcomes. For this reason, we will analyze the data and identify positive correlation by using SPSS software. Correlation coefficients close to +1 or -1 signify a very strong positive or negative correlation, and a coefficient approaching zero indicates a very weak correlation (Ibrahim, 2022). It is anticipated that the creation and implementation of "Mathepoly" will embody a significant result, indicate that gamification through Mathepoly increase student motivation and engagement.

Therefore, the objectives of this study are to identify the impact of Gamification through Mathepoly on students' perception towards motivation and engagement in learning Mathematics. Also, to determine the effect of Gamification through Mathepoly on the relationship between motivation and engagement. Other than that, it is to investigate students' learning experiences through gamification using Mathepoly.

2. Literature Review

Gamification in Mathematics

Gamification in education nowadays is widely used especially in teaching and learning contexts. Gamification in definition is the process of integrating two main components, non-game context, like education collaborating with game elements (Dustman, King-Keller, & Marquez, 2021). There are wide elements involved in gamification, especially in education, such as combining elements of challenges, stages, and rewards to the students in the teaching and learning process. The integration of gamified learning of Mathematics could lead to effective tools to enhance students' understanding and performance as well as assisting teachers and educators to give an alternative way in conducting classes rather than using conventional and traditional methods of teaching. Besides, gamification can motivate students, relax their mind, and reinforce their habits towards lessons especially in Mathematics (Tajeddin & Arabkhedri, 2020).

Impact on Motivation and Engagement

Gamification is one of the ways to increase students' motivation and engagement towards learning. Motivation is the internal mechanism that provides an individual with the energy to direct their efforts toward achieving a specific goal (Bandura, 2012). On the other hand, engagement refers to the manifestation of that drive; an action that facilitates the accomplishment of a goal (Leal & Córdova, 2021).

Self-Determination Theory (SDT)

In the realm of gamification, Self-Determination Theory (SDT) stands out as a widely utilized framework for comprehending the motivational capacity of games. Based on SDT, learners

have a natural tendency to take part in learning environments, a motivation that is enhanced by the three psychological needs namely autonomy, competence and relatedness with others (Deci & Ryan, 2016). Autonomy is defined as the freedom to select the challenges one wishes to tackle; competence is related to the sense of mastering the given challenge, while relatedness pertains to the feelings of acknowledgment and inclusion that arise from these engagements (Manzano-León et al., 2021). Games aim to integrate these principles to cultivate an innate drive within students. The application of gamification establishes a foundation for students and teachers to maintain a mutually beneficial relationship (Landers & Callan, 2011). This mutually dependent relationship is fostered by a well-balanced blend of external and internal elements designed to improve authentic learning experiences.

Keller's ARCS model

Keller's ARCS model is one that is used to determine the degree of motivation in technology and education. Since the goal of this approach is to increase and sustain student motivation, all the categories must be included in the motivational techniques employed in the teaching processes. According to Keller (1987), the ARCS model's categories include 4 constructs which are attention, relevance, confidence, and satisfaction (ARCS).

Attention indicates that students need to discover contents they interact with appealing to direct their focus where it can be achieved through various ways including promoting participation and using visual demonstrations. Meanwhile, confidence means letting the students participate in activities that are incredibly challenging. Apart from that, satisfaction refers to the situation where the students feel satisfied with their interactions in a course due to provision of compelling and engaging aspects like rewards and immediate feedback (Putz & Treiblmaier, 2015).

Relevance implies that students must identify the present and future value of a course for the course to appeal to them. Since this construct does not suit the nature of learning Mathematics among the students of CFS IIUM, thus, in this study, relevant (R) was replaced with perceived learning effects (PLE).

A student who engages actively in the academic process experiences a greater sense of belonging. Recent studies have demonstrated that gamification, particularly in the short run, can enhance engagement levels positively by cultivating a more pleasant atmosphere. In this study, the construct of engagement is examined through two distinct dimensions: emotional and cognitive. Emotional engagement pertains to positive responses towards academic settings, encompassing enjoyment and the sense of affiliation. Conversely, cognitive engagement involves the development of strategic learning abilities, incentives, and proficiency in addressing challenges (Putz & Treiblmaier, 2015).

3. Methodology

Research Design

This study employed a quantitative analysis to examine the impact of gamification in Mathematics education through the creation and implementation of Mathepoly among students from the Centre for Foundation Studies, IIUM. The study uses a convenience sampling technique by selecting a sample of 100 participants from several sections to play Mathepoly. The study was made easier to conduct because the participants were students who the researcher taught.

The game was played for a maximum of 1 hour and 30 minutes. After the gamification session, students completed the questionnaire, and their responses were collected for analysis. Data analysis was conducted using SPSS. The demographic data was analysed first, then the quantitative analysis was done towards the survey which included 20 items of 5-Likert scale questions, adapted from Baydas and Cicek (2019). Descriptive analysis and correlation analysis were employed in this study.

The study focused on 5 constructs to measure student's perceptions of the gamification learning experiences of Mathepoly, specifically on their engagement and motivation. The 5 constructs are perceived learning effect, attention, confidence, satisfaction and engagement. Based on table 1, the reliability of the constructs was confirmed with Cronbach's alpha values ranging from 0.844 to 0.891 (Streiner, 2003).

Table 1: Reliability Analysis.

Construct	Cronbach's Alpha	N of Items
Perceived learning effect (PLE)	0.844	4
Attention (ATT)	0.876	4
Confidence (CON)	0.891	4
Satisfaction (SAT)	0.870	4
Engagement (ENG)	0.871	4

The limitation of this study comes from the sampling technique used which is convenience sampling since it is not random. Due to the limited sample's response, the participants chosen might not be the genuine representative of CFS IIUM students or others in different educational backgrounds. Response bias is also a concern since there are high chances that the probability of students will give a more acceptable response rather than unbiased criticism because they know the researcher. Furthermore, self-selection bias could be one of the limitations in this study. The study may produce better results since the volunteers may have been more motivated and more incline to gamification. To address this matter, future studies may employ stratified or random sampling techniques to overcome this restriction and guarantee a complete and more representative sample.

Gamification System: Mathepoly

Monopoly is the popular board game which uses the elements of real estate together with the iconic world places and aims for the players to bankrupt their opponents. Inspired by the Monopoly board game, Mathepoly uses the same approach in incorporating Mathematics subjects and gamification aspects. Other than that, the new approach in playing Mathepoly is infusing Mathematical concepts and technology. Mathepoly board game can be played by nine players (students), four pairs for each game and one student acts as a banker as well as timekeeper. The Mathepoly physical elements like the board game itself, a die, colourful stickers for indicating sold properties on the board, title deeds, and chance cards act as the interesting elements for the students to fully use this game board as their alternative way for learning Mathematics.

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Figure 1: Mathepoly board

Based on figure 1, there are 24 boxes on the Mathepoly board, 16 of them are the slots for properties, 4 slots for 'Please take a chance card' and the remaining slots are the starting points, penalties and advantages offered to the players. 17 Sustainable Development Goals (SDG) introductory figures are placed at the centre of the board as well as 7 missions of IIUM information, which act as an added value for this game. The display on the properties of Mathepoly Board are the iconic places of Centre for Foundation Studies, International Islamic University Malaysia Campus in Gambang as their properties to be bought by the players. The players will be given RM10,000 for their first rounds and will be given RM1,400 after they complete each round.

The value of the properties is stated on the Title Deeds together with the Quick-Response (QR) code which is the link to the Quizizz's online platform. The value of the properties throughout the Mathepoly board are different for each slot depending on the sub-topics in Topic of Derivative/Differentiation. This topic offered in Mathepoly is from the Calculus subject, MAT0134 (Mathematics III). The level of the questions for each slot were divided into two categories, which are Level 1: True/False Questions and Level 2: Multi Choice Questions MCQ). Time allocation to play this game is around one-and-a-half-hour maximum and each team (pairing) is required to roll a single die to move across the board.

The first round is the 'Ta'aruf" (orientation) round and players cannot buy any properties yet. After completing the first round, the players will make their move and plan their strategies to buy the properties on the slots they landed on. Once they buy the property, they will be given Title Deeds, act as a certificate of the ownership of a property. If the opponents land on the

bought properties, the opponents have to answer a question (based on the subtopic stipulated on each property), starting with the True/False Question by scanning the QR Code on the Title Deed given by the owner. Once the opponent gets the right answer, they only need to pay half price of the question price stated on the Title Deed. Otherwise, they need to pay full price. The bigger number of the slot, such as Slot 16 is different compared to Slot 3. This approach is also implemented to the value of the properties on the slot. In other words, the slot's number is directly proportional to price properties, degree of topic's difficulty as well as question price. After 45 minutes played, the difficulty level of questions will be upgraded to Level 2: MCQ along with the different prices of the questions. At the end of the game, each team needs to total up their amount of money left together with the price of the owned properties and the highest value for both elements collectively will be the winner.

4. Result and Discussion

In this section, we will present the data analysis of the survey form. The demographic data were analysed first. Table 2 presented the participants' gender. In terms of gender, from a total of 100 students participated in the gamification sessions, the participants consist of 29 female students and 71 male students. According to table 3, the participants comprised of 84% engineering students and 16% physical science students.

Table 2: Respondents' gender.

Frequency	Percent
female	29
male	71
Total	100

Table 3: Respondents' course.

Frequency	Percent
ENGIN	84
PHYSC	16
Total	100

Apart from that, the CGPA of the participants were also considered in this demographic data. Based on CGPA, we divided them into 2 categories, which are high achievers and low achievers. High achievers were identified as those with a CGPA of at least 3.0, while low achievers had a CGPA below 3.0. Table 4 presented the data, where 26 students were low achiever students, and 74 students were considered as high achiever.

Table 4: Respondents' CGPA.

Frequency	Percent
LOW ACHIEVER	26
HIGH ACHIEVER	74
Total	100

Next, we will analyse the quantitative data based on the 20 items in the survey. Based on the descriptive statistics presented in Table 5, it has shown that the participants generally had positive perception regarding the gamification elements of Mathepoly across all measured constructs. The mean scores for all the constructs are relatively high with perceived learning effect (PLE), attention (ATT), satisfaction (SAT) and engagement (ENG) all having above 4.5 on a 5-point scale. This indicates that students found Mathepoly significantly beneficial in

enhancing their learning and attention while providing a satisfactory and engaging experience. SAT has the highest mean score of 4.73 that reflects a strong overall positive response to gamified approach. ATT and PLE also have high mean scores of 4.71 and 4.64 respectively, indicating Mathepoly is an effective learning tool while keeping students focused. Lowest mean score is Confidence (CON) with a value of 4.47 but having highest standard deviation among the constructs.

Despite having the lowest mean score on any construct, the CON demonstrated good internal consistency (Cronbach's alpha: 0.891), suggesting that the activity steadily increased students' confidence despite their feelings of challenge. This finding is comparable with studies done by König (2021) that focused on the iterative process of learning through gamification, where competence and confidence are gradually built through problem-solving and repeated mistakes.

Table 5: Descriptive Statistics.

	Minimum	Maximum	Mean	Std. Deviation
Perceived Learning Effect (PLE)	3.00	5.00	4.6425	.49906
Attention (ATT)	3.00	5.00	4.7075	.44673
Confidence (CON)	2.00	5.00	4.4725	.63950
Satisfaction (SAT)	3.00	5.00	4.7275	.46343
Engagement (ENG)	2.25	5.00	4.5875	.57667
Valid N (listwise)				

The high mean scores and relatively low standard deviations across the constructs suggest that Mathepoly was well-received, effectively engaging students and enhancing their learning experience. PLE, ATT, CON and SAT are the constructs in measuring motivation. Thus, the mean score of these constructs is able to measure students' motivation. It is important to evaluate how Mathepoly increases students' engagement and motivation. Thus, the study aimed to investigate the relationship between motivation and student engagement. Given that data did not meet assumptions of normality, Spearman's rho correlation was employed for the analysis using SPSS.

Table 6 below represents the Spearman's rho correlation result. There is a strong positive relationship between motivation and engagement with a correlation coefficient of 0.841. This correlation is statistically significant at the level 0.01 indicating that as motivation increases, engagement also increases.

Table 6: Correlation

			Motivation	Engagement
Spearman's rho	Motivation	Correlation Coefficient	1.000	.841**
		Sig. (2-tailed)	.	.000
		N	100	100
	Engagement	Correlation Coefficient	.841**	1.000
		Sig. (2-tailed)	.000	.
		N	100	100

***. Correlation is significant at the 0.01 level (2-tailed).*

Table 7: Correlation: Low Achievers versus High Achievers

	LOW_HIGH_CGPA			Motivation	Engagement
Spearman's rho	LA	Motivation	Correlation Coefficient	1.000	.897**
			Sig. (2-tailed)	.	.000
			N	26	26
		Engagement	Correlation Coefficient	.897**	1.000
			Sig. (2-tailed)	.000	.
			N	26	26
	HA	Motivation	Correlation Coefficient	1.000	.827**
			Sig. (2-tailed)	.	.000
			N	74	74
		Engagement	Correlation Coefficient	.827**	1.000
			Sig. (2-tailed)	.000	.
			N	74	74

***. Correlation is significant at the 0.01 level (2-tailed).*

Based on table 7, it is evident that low achievers exhibit a higher correlation between motivation and engagement compared to high achievers. Specifically, the Spearman's rho correlation coefficient for low achievers is 0.897, indicating a very strong positive relationship between motivation and engagement in this group. In contrast, high achievers have slightly lower correlation coefficients of 0.827 but still reflect a strong positive relationship. Both correlations are statistically significant at the 0.01 level. This suggests that while motivation significantly impacts engagement for both groups, the effect is more pronounced among low achievers.

These findings are consistent with the existing research that supports how gamification can improve the learning outcomes. Similar to the high level of engagement seen in this study, Attali and Arieli-Attali (2015) showed that gamification in higher education, such as using narrative-driven games, significantly raised students' excitement, attention and motivation to learn. In a similar vein, Hemmings, Grootenboer and Kay (2011) discovered that adding game components to the assessments increased students' motivation and performance, reflecting Mathepoly beneficial effects on students' focus and self-assurance.

5. Conclusion

The study investigated the relationship between motivations and student engagement with a specific focus on how this relationship varies between low achievers and high achievers. The descriptive statistics indicated generally positive perceptions of the motivations through Mathepoly across various constructs including PLE, ATT, CON and SAT with ENG. Spearman's rho correlation analysis revealed a strong positive relationship between motivation and engagement for both low and high achievers. This suggest that gamification is an effective strategy for enhancing student engagement through increased gamified learning effect, particularly among low achievers.

Overall, the study supports the use of gamifications as valuable pedagogical tool that can enhance student engagement that can potentially leading to improved educational outcomes and performance. The stronger correlation observed among low achievers implies that motivations might be particulars beneficial for this group in helping to bridge engagement gap and support their academic success.

Acknowledgements

The authors acknowledge Department of Mathematics, Centre for Foundation Studies, International Islamic University Malaysia for the opportunity to carry out this innovative research. We are grateful to the CFS IIUM students for their ongoing participation in this study and support of the Mathepoly game.

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