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GENDER DIFFERENCES IN THE EFFECTIVENESS OF GAMIFICATION IN MATHEMATICS EDUCATION AMONG SECONDARY SCHOOL STUDENTS IN MUKAH, SARAWAK

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Abstract:

Even though gamification has gained popularity in education, limited research has been conducted on gender differences in how gamified approaches are implemented in secondary school mathematics. This study examined the effect of gamification on 59 students from three different secondary schools in Mukah, Sarawak, who participated in a one-day mathematics program. This study found that female students are more likely to be motivated, experience greater enjoyment, have greater perceptions of usefulness and intend to use the mathematics gamification than male students. Statistically significant differences are found in this regard. Besides, the data showed that both male and female students' perceived usefulness was significantly related to their enjoyment and willingness to use mathematics gamification but not their motivation and engagement. It is clear from these results that educators must consider gender-specific responses in order to make an effective mathematics gamification. However, the results of this study can only be applied to the program since nonparametric analyses were used. Thus, larger studies with broader participation and pre-post evaluations may be useful for future research to obtain more robust evidence concerning the differences between the genders.

Keywords:

Enjoyment, Engagement, Motivation, Perceived Usefulness, Intention to Use

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Introduction

Education in schools is fundamental to shaping the intellectual, social, and emotional development of individuals (Attah et al., 2024). Transformative educational journeys foster a vital role in building the knowledge, skills, and values needed for personal growth and active engagement among students. Central to the educational process, effective teaching and learning are fundamental elements in empowering students to become knowledgeable and active participants in the classroom. Hence, educators must embrace creativity and innovation in delivering lessons to ensure that learning is effective and engaging, ultimately fostering greater student achievement and success.

In general, the common teaching method applied in most schools is teacher-centered, focusing on practicing exercises and memorizing tips and formulas as the primary methods of learning (Kassim & Zakaria, 2015). This method aligns with the traditional learning method used by other teachers in schools. Nonetheless, according to Che Mansor and Rosly (2024), the traditional teaching method does not completely comply with the learning objectives and students' success, especially in understanding mathematical concepts since the learning process is primarily focused within the classroom without additional teaching aids. To address this issue, innovative strategies, such as integrating physical gamification into education, are urgently needed to bridge the gap by offering a more interactive and stimulating learning approach. By engaging students' bodies and minds, physical gamification has the potential to revolutionize the way knowledge is delivered and retained. The implementation of gamification in learning is also in line with the recommendations of the World Health Organization (WHO), which advocate for adults to engage in at least 150 minutes of moderate-intensity physical activity or 75 minutes of vigorous-intensity physical activity each week (WHO, 2020a, b) to promote healthy lifestyles among students.

Murtazaev and Shukrulloev (2024) mentioned that the mathematics education area can be particularly challenging for the learning process when using traditional methods, as this method often relies heavily on rote memorization and abstract concepts that may not engage students effectively. In contrast, gamification offers an innovative approach to learning, making complex mathematical concepts more interactive, enjoyable, and accessible, which can enhance student engagement and understanding. Additionally, gamified math education is a physical activity that integrates movement with academic or skill-based objectives. It ranges from simple games to more complex set-ups or more extensive movements. By requiring students to use their minds and bodies, these games create a dynamic learning environment catering to diverse learning styles.

Currently, the Ministry of Education in Malaysia has introduced 21st-century learning, which aims to elevate the educational experience by incorporating technology into classrooms. Hence, gamification learning could be integral to this approach, focusing on fostering innovation and making the learning process more interactive (Wahid, 2020). This shift is intended to enhance the quality of education at a national level. Nonetheless, Sedig (2008) points out that many students, particularly in secondary schools, recognize the challenges and complexities involved in learning Mathematics. A study by Gafoor and Kurukkan (2015) revealed that many students view Mathematics as a challenging subject, primarily due to difficulties in grasping and retaining the concepts. Additionally, the absence of interactive, gamification learning in Mathematics classrooms could negatively impact students' performance in the subject. Therefore, Udjaja et al. (2018) stated that gamification is the most suitable teaching method for

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mathematics, as it combines classroom instruction with educational games. This approach fosters a balance between traditional learning and interactive play, enhancing learning efficiency by offering students an engaging way to learn mathematics while supporting teachers in explaining mathematical concepts. Mathematics learning can also become more interactive and interesting, making it easier to deliver mathematical concepts effectively.

In addition to implementing the gamification learning approach for Mathematics, researchers must also examine its effectiveness in secondary schools. To date, several researchers (Attah et al., 2024; Ariffin et al., 2024; Zainuddin, 2023; Piquer-Martinez et al., 2024; Almusharraf et al., 2023; Roslan et al., 2021; Cahyani, 2016) have conducted a study to investigate the effectiveness of education in gamification among students based on certain variables, for instance, the enjoyment, motivation, engagement, ease of use, attitudes, perceived usefulness, intention to use and demographic variable of gender. However, there is a noticeable gap in the literature review regarding studies on the effectiveness of gamification in mathematics education among secondary school students of different genders. Thus, this problem requires further attention to be explored.

Eventually, to fill the gap, this study was conducted to investigate the effectiveness of gamification in mathematics education among secondary school students based on gender differences to assess the effectiveness of this gamification learning approach between genders. The study also aims to explore the correlation between the key variables in the context of gamified learning. By identifying variables with significant correlations, educators can design effective gamified mathematics interventions that can improve learning outcomes in the classroom, especially for students who struggle with mathematics. In addition, the study results could contribute to achieving the Malaysian Ministry of Education's goal of embracing the new norm of 21st-century learning. Furthermore, this study could assist in a deeper understanding of the significant differences between genders in relation to the variables explored, offering valuable insights for addressing challenges or improving the types of games utilized in Mathematics education.

Literature Review

Mathematics plays an important role in Malaysia's education system, serving as a foundation for scientific, technological, and economic advancement. Recognized as a core subject in the national curriculum, mathematics is essential not only for academic achievement but also for developing analytical skills and problem-solving abilities for success across various disciplines (Rios et al., 2024). Mathematical concepts are applied in a broad range of everyday scenarios, from simple tasks like calculating discounts, profit, and loss (Suherman et al., 2020; Wibawa et al., 2022) to more complex applications in diverse fields such as engineering, economics, pharmaceutics, and accounting (López-Díaz & Peña, 2021). Furthermore, mathematics is widely recognized as a fundamental discipline and the cornerstone of advancements in science and technology (Yeh et al., 2019).

Malaysia, under the Ministry of Education (MOE), has demonstrated a strong commitment to ensuring that science and mathematics education aligns with international standards. Since 1999, Malaysia has actively participated in the Trends in International Mathematics and Science Study (TIMSS), organized by the International Association for the Evaluation of Educational Achievement (IEA). TIMSS, conducted every four years, collects valuable data on curricula, teaching practices, and other factors influencing learning outcomes, contributing

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to the continuous improvement of education quality, particularly in science and mathematics. In 2003, the implementation of the *Pengajaran dan Pembelajaran Sains dan Matematik dalam Bahasa Inggeris* (PPSMI) policy further underscored Malaysia's dedication to strengthening education by using English as the medium of instruction for these subjects, aiming to better prepare students for global challenges (Tan & Lan, 2011). However, a year later, Hashim Yaacob reported that only 43.18% of students were enrolled in the Science and Technology streams, falling short of MOE's target of 60% for upper secondary schools. This shortfall indicates challenges in students mastering mathematics, as strong performance in mathematics was a prerequisite for selection into these streams.

The importance of mathematics and science education is further emphasized in the Malaysian Education Blueprint (2013-2025), which aims to foster higher-order thinking skills (HOTS) and strengthen Science, Technology, Engineering, and Mathematics (STEM) learning. It was stated in Shift 1 among the Blueprint's 11 Shifts, which focuses on providing equitable access to quality education for all students, including improvements in STEM education (MOE, 2018). In 2021, MOE revealed that Malaysia's TIMSS 2019 results showed that students initially performed above the international average in mathematics during the 1999 cycle. However, the subsequent cycles, particularly in 2007 and 2011, revealed a decline in performance. This prompted the Blueprint to set an aspiration to position Malaysia among the top one-third of TIMSS participants within the next 15 years. This initiative aligns with the nation's goal of producing a competitive STEM workforce, which is essential for achieving high-income economic status.

All the initiatives undertaken by the MOE underscore the importance of mathematics education, STEM, and equipping students with 21st-century skills to ensure Malaysia remains on the right path toward becoming a developed nation. Despite these efforts, challenges persist, including declining mathematics performance, a low number of students opting for the science stream, varying proficiency levels among learners, and the need for innovative teaching methods. These issues highlight the critical need to adapt teaching approaches to ensure equitable access to and engagement in mathematics learning across the country.

Although mathematics holds undeniable significance, it is often perceived by students as challenging, tedious, impractical, and requiring exceptional abilities that are not universally attainable (Ignacio, Nieto & Barona, 2006). Mathematics curricula are deeply involved in developing HOTS, including problem-solving, reasoning, critical thinking, and computational thinking. However, educators face significant challenges in stimulating students' HOTS effectively (Anggoro et al., 2024). To address this, educators must adopt creative teaching and learning strategies while ensuring the syllabus is comprehensively delivered. Traditional teaching methods, such as rote memorization, lecture-based instruction, and drill exercises, have long been the cornerstone of mathematics education. While these approaches emphasize accuracy and systematic problem-solving, they often lack engagement, particularly for students in the 21st century who are accustomed to dynamic and interactive experiences.

Deterding et al. (2011) define gamification as incorporating game-like elements to enhance user engagement by making activities enjoyable and fun. Integrating gamification into teaching and learning promotes active student participation, making the learning process more engaging and tangible. Ismail et al. (2018) further emphasize that gamification, combined with creativity and problem-based learning (PBL), serves as an innovative educational approach that

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encourages student activism and engagement. Supporting this, Taesotikul et al. (2021) highlight that incorporating game mechanics, narratives, and dynamics creates a gaming environment that sparks imagination and fosters student creativity. In light of these findings, the present research highlights the gamification in mathematics education among secondary school students. This innovative approach integrates challenges, rewards, and storytelling to make mathematics more accessible and enjoyable. By combining traditional teaching practices with gamification strategies, educators can foster a deeper understanding of mathematical concepts while enhancing student engagement.

Understanding students' learning styles in the classroom helps educators design strategies to implement the most effective teaching methods for better comprehension. This section explores the variations in learning styles among students of different genders. According to Kolb's (1984) theory, there are four distinct learning styles: assimilation, accommodation, convergent, and divergent. The study by Ghazivakili (2014) identified a significant relationship between learning style and gender. It also found that the most popular learning style among the students was the convergent style, followed by the assimilation style. Kolb (1984; 1985) explains that convergent learners integrate abstract conceptualization with active experimentation, turning abstract ideas into practical solutions by addressing problems. In contrast, assimilator learners combine abstract conceptualization with reflective observation, excelling at structuring information into logical systems.

The study conducted by Ganesen et al. (2020) compares the differences in Kolb's learning styles based on the gender of students. This study focuses on teaching algebra to secondary school students. Assimilation is the most favoured learning style, with males showing a greater preference for assimilation-based learning than females. Learners with this style prefer acquiring knowledge through observation and reflective thinking. This study recommends incorporating more problem-based tasks after presenting the key concepts of the topic. The converging learning style is the second most preferred approach to studying algebra, with male students favoring this learning style more than female students. This type of learner prefers activities such as decision-making, problem-solving, and applying ideas in practical situations. The accommodation learning style ranks as the third most favoured method for learning algebra, while the diverging learning style is the least preferred.

Ling and Ching (2010) reported that male and female students have distinct preferred learning styles. Male students are more inclined to form personal relationships with the instructor than female students. In contrast, female students sought more detailed information about assignment requirements and instructions than male students. The study also found that male students were less inclined to learn independently and alone compared to female students, who preferred solitary and independent learning. Female students demonstrated a significantly higher preference for engaging in verbal communication and working with words than male students, who were reluctant to learn about language and words. Additionally, male students showed a greater preference for interacting with inanimate objects during their studies compared to female students. Female students preferred learning through interaction with people, while male students favoured learning through direct experience.

Based on the research by Sengodan and Iksan (2012), students do not adhere to a single learning style but engage with various learning styles and intrinsic motivations. Among all the learning styles, the surface approach is the most preferred and commonly used by students when

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learning mathematics. Students often exhibit a tendency to rely on others, reflected in behaviours such as waiting for instructions from instructors to complete the given tasks and focusing on memorizing notes rather than fully understanding the concept. Their study reveals a notable difference between males and females in organizational learning style, while no significant differences are observed in surface approach or hard work learning styles. This finding is consistent with the research conducted by Aziz et al. (2006). Compared to male students, female students are more systematic and organised in their note-taking. Female students also prefer to create their own notes when revising. This result is also reflected in how they plan their answers during exams.

Ivan and Maat (2024) discovered that secondary school students predominantly adopt a dependent learning style when studying mathematics. They consistently rely on teachers and classmates for support during the learning process. Educators should promote independent learning skills to support students who tend to employ a dependent learning style. Educators can implement learning practices encouraging critical thinking, such as employing open-ended questions requiring deep thinking and independent study. Adopting a collaborative approach, where students work together to solve mathematical problems, can boost their confidence, improve social skills, and enhance their understanding of mathematical concepts. This research does not highlight gender differences in learning styles.

Even though many studies agree that learning styles differ based on gender, a few studies contradict this claim. Ahmad et al. (2021) concluded that there were no differences in learning styles between male and female students. The difference in sample size and the varying ratio of males to females may have contributed to the diverse results in their study. The study also found that the most popular learning style among secondary school students was visual, followed by auditory and kinesthetic.

Methodology

A one-day mathematics intervention programme was conducted at the Universiti Teknologi MARA (UiTM) Mukah Campus in late April 2024, involving participants from three secondary schools in Mukah. Gamification was incorporated into the program to create an enjoyable experience with three learning games by utilizing competition and reward system elements. The initiative specifically targeted Form 5 students who have difficulty with mathematics. There were a total of 30 students selected from each school by their teachers. Despite this, only 59 of the 60 students registered attended the programme. Thus, all 59 students who attended the programme were included as samples of this study to measure the effectiveness of gamification among them.

A physical questionnaire in Malay language that consisted of three sections was distributed once the program ended. The initial section focuses on questions pertaining to the demographic characteristics of respondents, such as gender and religious beliefs. The second section measures the variables for enjoyment, engagement and motivation adopted from Cahyani (2016) using a 5-Likert scale from “strongly disagree” to “strongly agree”. A 5-point Likert scale is also used in the final section of the questionnaire to assess perceived usefulness (Davis, 1989) and intention to use gamification (Wangpipatwong et al., 2008) among respondents, with ratings ranging from "very poor" to "very good’. This instrument was also validated through a pilot study involving participants outside the scope of the research. The findings revealed that

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all variables achieved a Cronbach's alpha value exceeding 0.6, which is considered acceptable by Hulin et al. (2001).

All the data was analyzed using SPSS version 29 at a 5% significant level. Descriptive statistics, such as frequency and percentage, were used to determine the characteristics of the collected data. In this study, data were found to be non-normal; therefore, nonparametric methods were more appropriate. Thus, inferential statistics were used to determine whether gamification was effective based on gender using a Mann-Whitney test. Next, Spearman-Rho tests were used to assess the correlation among the examined variables. The Spearman-Rho coefficient is interpreted according to Dancey and Reidy (2007) as follows:

Table 1: Spearman's Correlation Coefficient Interpretation

Correlation Coefficient			Interpretation
1.00	or	-1.00	Perfect
0.70 to 0.99	or	-0.70 to -0.99	Strong
0.40 to 0.69	or	-0.40 to -0.69	Moderate
0.10 to 0.39	or	-0.10 to -0.39	Weak
0			Zero

Results and Discussion

Table 2 shows the demographic profile of 59 respondents involved in this study. Most of them are female (76.3%). In terms of religion, the largest group identified as Muslim, representing 59.3% (n = 35), followed by Christian 39.9% (n = 19). Among ethnic groups, the Melanau ethnic group represented the largest proportion at 59.3% (n = 35). It is consistent with the ethnic composition of Mukah, which is predominantly Melanau. This was followed by the Chinese (15.3%, n = 9), the Malays (13.6%, n = 8), the Bidayuh (5.1%, n = 3), the Iban (5.1%, n=3), and the Kadazan (1.7%, n = 1).

Table 2: Demographic Profile of Respondents by Gender, Religion, and Race

	Frequency	Percentage
Gender		
Male	14	23.7%
Female	45	76.3%
Religion		
Muslim	35	59.3%
Christian	19	32.2%
Buddhist	5	8.5%
Ethnic		
Melanau	35	59.3%
Chinese	9	15.3%
Malay	8	13.6%
Bidayuh	3	5.1%
Iban	3	5.1%
Kadazan	1	1.7%

Table 3 shows the difference between males and females in terms of their level of motivation, enjoyment, engagement, perceived usefulness, and intention to use gamification among students. The analysis results indicate that all examined variables were statistically significant,

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except for engagement levels ($p > 0.05$). This means that male and female students experienced similar levels of engagement in this study, which is consistent with the study done by Ariffin et al. (2024).

Mathematical gamification enjoyment results in significant differences between genders, with females experiencing greater enjoyment (Median = 4.200) than males (Median = 3.633). Besides, motivation to play and complete the games was found to be significantly higher among females (Median = 4) than males (Median = 3.583). This contrasts with a previous study done by Almusharraf et al. (2023), which found that motivation when using Kahoot! in learning the English language is not dominated by either gender, as both females and males respond similarly. Moreover, recent research by Piquer-Martinez et al. (2024) suggests that male students demonstrate higher motivation to gamified elements than female students.

Based on students' perceptions or beliefs about using gamification to enhance their mathematics knowledge, females (Median = 4) reported significantly higher perceived usefulness than males (Median = 3.833). The results indicate that female students held more positive views about the benefits of gamified approaches in enhancing their understanding of mathematics. A significant gender difference was also found in intention to use, with females (Median = 4.5) scoring higher than male students (Median = 4). Based on these findings, female students are more likely than males to recognize the potential benefits of gamification and express a greater willingness to use such approaches in their mathematics education.

Table 3: Male-Female Comparison using Mann Whitney U Test

	Gender	Median	Mean Rank	Mann-Whitney U	Z-value	p-value
Enjoyment	Male	3.633	19.25	164.5	-2.697	0.007
	Female	4.200	33.34			
Engagement	Male	3.450	24.32	235.5	-1.429	0.153
	Female	3.750	31.77			
Motivation	Male	3.583	16.11	120.5	-3.498	<0.001
	Female	4.000	34.32			
Perceived Usefulness	Male	3.833	21.00	189.0	-2.298	0.022
	Female	4.000	32.80			
Intention to Use	Male	4.000	20.61	183.5	-2.453	0.014
	Female	4.500	32.92			

Bonett and Wright (2000) recommend a minimum sample size of 25 for reliable results when using Spearman's rho. Due to an insufficient sample size, the following analysis, which examines the correlation among variables, will not be conducted separately by gender, as represented in Table 4.

As shown in the table below, enjoyment has a significant moderate positive correlation with engagement ($\rho = 0.43$, $p < 0.01$), motivation ($\rho = 0.53$, $p < 0.01$), and perceived usefulness ($\rho = 0.45$, $p < 0.01$). According to studies by Latiff et al. (2024) and Cheng & Liang (2022), gamification enjoyment has also been correlated with academic engagement in the classroom. Incorporating fun gamification into the learning process lets students fail without feeling discouraged while also enjoying the game, which motivates them to continue trying and

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persevering (Cahyani, 2016). Despite this, the correlation between enjoyment and intention to use is not statistically significant ($\rho = 0.18$, $p > 0.05$). This indicates that although enjoying the experience is important and related to other variables, it does not correlate with adopting or continuing to use gamification in the future. This contrasts with the study by Roslan et al. (2021) on gamified e-quiz mobile applications that significantly correlated intention to use with enjoyment among students in higher education.

Moreover, the analyses indicate that engagement in mathematical gamification is significantly correlated with motivation ($\rho = 0.37$, $p < 0.05$) and perceived usefulness ($\rho = 0.38$, $p < 0.05$). It is clear that higher engagement with gamified mathematical elements was associated with higher motivation and greater perceived usefulness. Even so, the correlations were weak. In spite of these, engagement with the game does not appear to be associated with a desire to use it in the future ($\rho = 0.20$, $p > 0.05$). Gamified learning tools do not necessarily lead to a stronger intention to continue using them in the future just because they increase engagement levels.

A significant moderate positive correlation was found between motivation and perceived usefulness ($\rho = 0.43$, $p < 0.05$). This finding agrees with Ariffin et al. (2024), highlighting that students' motivation to engage using gamification significantly correlates with their perceptions of its usefulness. Similarly, the correlation between motivation and intention to use gamification is positively and significantly correlated ($\rho = 0.27$, $p < 0.05$). It means that motivation level is important in shaping students' perceptions of the benefits of gamification and their intention to engage with it in the future. However, the strength of these significant correlations was moderate.

The strongest correlation was found between perceived usefulness and intention to use ($\rho = 0.68$, $p < 0.05$). This aligns with Roslan et al.'s findings (2021), where intention to continue strongly correlates with perceived usefulness. This suggests that the intention of students to adopt gamification in mathematics education is highly related to their perceptions of its usefulness. In other words, the usefulness of the game is crucial in influencing students to continue using gamified learning tools. If the game is useless to them, they will not intend to play it again.

Table 4: Results of Spearman-Rho Correlation Analysis

	1	2	3	4
(1) Enjoyment				
(2) Engagement	0.43**			
(3) Motivation	0.53**	0.37**		
(4) Perceived Usefulness	0.45**	0.38**	0.43**	
(5) Intention to Use	0.18	0.20	0.27**	0.68**

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Conclusion

Gamification as a tool for the learning process should provide a fun experience, encourage engagement and inspire players to continue to be actively involved. Besides improving mathematical knowledge, gamification should inspire players to play again to improve their knowledge. In spite of this, each student has a personal opinion regarding the use of games in education. In this study, gender differences between males and females were compared to

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measure the effectiveness of gamification with students from three different schools. The results found that enjoyment, motivation, perceived usefulness, and intention to use were all significantly higher among females than male students in the secondary schools located in Mukah, Sarawak. This indicates that the implementation of gamification in mathematics education has been more effective in stimulating these factors for females with mathematical concepts. However, no significant gender difference was observed in engagement, suggesting that this variable may not be influenced by gender in this context. These findings demonstrate that educators and designers of gamified mathematics learning should reconsider gamification priorities and requirements for both genders. This reassessment is essential for enhancing the effectiveness of gamification for both genders. In light of this, it is important to acknowledge that the impact of gamification may not be the same for both genders.

In addition, the results also indicate that all the key variables were interrelated except for the intention to use, which showed no significant relationship with either enjoyment or engagement. However, the perceived usefulness was shown to have the most robust correlation with students' intention to use mathematical gamification. Therefore, this can play an important role in driving the long-term adoption of mathematical gamification among students by increasing perceived usefulness. Educators should focus not only on the fun aspects of the game but also explain to students how gamification can be used to enhance their mathematics education and indirectly encourage them to use gamification as a learning tool in the future.

For future research, it would be beneficial to use larger samples in order to validate the findings further and use parametric analyses, thus enhancing their generalizability and reliability. Moreover, evaluations should be conducted before and after the program to gain a better understanding of its impact over time. It may also be possible for researchers to examine whether certain game mechanics or features significantly impact engagement, motivation, and learning outcomes from gamification in mathematics education in the future.

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