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TEACHER'S PERCEPTION OF GAME-BASED LEARNING FOR SUSTAINABLE QUALITY EDUCATION USING THE FUN LEARNING MATHEMATICS KIT

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Abstract: Utilising game-based learning as a dynamic teaching tool holds promise in enhancing mathematics education. This study investigates its impact, particularly on teachers' perceptions, through the implementation of the Fun Learning Mathematics Kit (FleMatics). Analysis of pre- and post-survey data from 40 secondary mathematics teachers in Petaling Jaya reveals a significant increase in perception following the implementation of FleMatics. Results indicate a consensus (97.5%) on the effectiveness of game-based learning in fostering student motivation and conceptual mastery. The study highlights FleMatics' potential to positively influence teaching practices and student engagement in mathematics classrooms, emphasising its role in advancing STEM education and aligning with Sustainable Development Goal 4 (SDG 4) objectives. Despite limitations, findings underscore the transformative potential of game-based learning in mathematics education and its contribution to global education goals and sustainable development.

Keywords: Game-based learning, STEM education, teachers' perception.

Introduction

Mathematics is a compulsory subject from early childhood education, primary school, secondary school, and continues in foundation-level studies. The integration of Science, Technology, Engineering, and Mathematics (STEM) in education aligns with the Sustainable Development Goal 4 (SDG 4) of quality education. By incorporating STEM into teaching and learning practices, educators aim to provide students with interdisciplinary and meaningful learning experiences. This approach not only enhances their understanding of these subjects but also fosters critical thinking and problem-solving skills, which are essential for achieving quality education. The use of many games in teaching and learning mathematics was applied, so, students were expected to learn and think that the subject is interesting and fun (Saputra *et al*., 2021). The integration of Science, Technology, Engineering, and Mathematics (STEM) in today's education aims to shift teaching and learning practices from traditional lecture-based teaching into those that are inquiry, game-based learning, and project-based to present interdisciplinary, meaningful learning experiences that could include two or more of the four main disciplines identified in STEM education.

Research on the use of game-based learning in mathematics education has shown positive perceptions from both teachers and students. One study reported that trainee teachers recognised the potential of game-based learning, despite a gap between academic and developer concepts of engagement (Tan, 2018). Studies found that students experienced improved psychosocial features of the learning environment, academic efficacy, and enjoyment of mathematics lessons when exposed to game-based learning (Afari, 2012; Rahim *et al*., 2020). Hands-on games

offer students the opportunity to experience success, satisfaction, active involvement, and gain confidence in their mathematical abilities (Rahim *et al.,* 2020). Furthermore, the use of game-based learning in mathematics is effective in promoting sustainable development goals, particularly in raising awareness and understanding of the SDGs (Ho *et al*., 2022). Collectively, these investigations suggest that the effective utilisation of game-based learning can improve both teacher and student perspectives on mathematics education, aligning with the objective in SDG 4, Quality Education.

A notable change in educational pedagogy is the incorporation of game-based learning into math classes, made possible by STEM learning-incorporated resources such as the Fun Learning Mathematics Kit. The way that these approaches are integrated into the classroom and the views of the teachers greatly influence their effectiveness. It is important to comprehend how teachers view the integration of games into mathematical instruction as educators investigate this dynamic approach. The adoption and application of game-based learning methodologies can be significantly impacted by their attitudes, beliefs, and experiences. This study examines teachers' perceptions of game-based learning in mathematical lessons through the implementation of the Fun Learning Mathematics Kit (FleMatics). Teachers can better utilise the power of game-based learning if they have a deeper awareness of teachers' perspectives.

Materials and Methods

Data Sampling

In this research, forty mathematics teachers from secondary schools in Petaling Jaya participated in the FleMatics training program. The participants were recruited through voluntary participation following a poster announcement distributed among schools in Petaling Jaya. This approach ensured inclusivity and aligned with the funding requirements of the Majlis Bandaraya Petaling Jaya (MBPJ) community grant, which supports education initiatives within the district. The recruitment posters highlighted the objectives of the study and invited teachers who were interested in innovative teaching approaches.

The interactive online training programme was held on 25 February 2022 from 3:00 p.m. to 5:00 p.m. The workshop is conducted online via Microsoft Teams in compliance with the government order issued during the Movement Control Order (MCO). This approach ensured the safety and well-being of all participants while allowing the continuity of professional development opportunities for teachers. Through the online medium, participants could still benefit from an interactive and engaging learning experience, leveraging digital tools to enhance their skills in teaching mathematics. The shift to online delivery also reflected adaptability in maintaining high-quality training during challenging circumstances. Furthermore, online platforms make it easier for educators from diverse locations in Petaling Jaya to participate without the need for travel, saving time and resources.

During the two hours training, several speakers explained the module in detail and showcased innovative activities like Number Race, Linear Equation Puzzle, and Number Base Maze to the teachers. These activities encourage students to solve mathematical problems in a fun and competitive format. Teachers learned how to use this game to foster excitement and sharpen mathematics skills in their physical classrooms or online medium. In addition, modules for the FleMatics workshop were designed to provide teachers with practical tools to make mathematics more dynamic and enjoyable while helping students to understand the concept easily.

Throughout the workshop sessions, quantitative data were gathered to enable an extensive assessment of the Fun Learning Mathematics Kit's impact on teacher views and methods of instruction, as well as its effectiveness. The study's materials and methodology allowed for a systematic examination of the introduction of game-based learning into

mathematical instruction, providing insightful information about the potential challenges and implications of applying innovative teaching methods to daily life. To further evaluate the program's outcomes, a post-mortem workshop was conducted at the Dorsett Grand Subang from 11 October 2024 to 13 October 2024. This session brought together two participating teachers, lecturers, and facilitators to discuss the program's effectiveness and identify areas for future improvement. During the workshop, teachers shared their experiences, reflections, and insights on implementing the Fun Learning Mathematics Kit. Key discussions focused on the challenges faced during the program, the observed impact on student engagement and understanding, and strategies for sustaining and scaling the initiative.

Module

The module introduced in this study is a game-based learning module, which is a non-digital board game, through this approach, students achieved better learning outcomes and motivation in the mathematics course than those who learned with the conventional technology-enhanced learning approach (Wang *et al*., 2018). The FleMatics Kit was developed upon the successful development of the previous module of Recreational Math, focusing on a fun learning approach (Hassan *et al*., 2021a; 2021b) and Easy Math, focusing on a self-learning, home-based module due to the COVID-19 lockdown restriction (Azman *et al*., 2022).

This module integrates secondary school chapters on number bases, polynomials, number systems, and equations such as quadratic and linear. These four topics were selected to introduce students to basic algebra and arithmetic concepts, which will encourage them to continue learning mathematics (Tan *et al*., 2019). This kit contains four board games and teachers can use it as an extra activity during mathematics lessons. Students who are disinterested in mathematics subject matter can benefit from game-based learning by participating in a collaborative, hands-on exercise that requires teamwork to solve (Kiili *et al*., 2018). This kit focuses more on establishing a fun learning environment for challenging subjects than on solving mathematical problems.

This study aimed to provide an extensive evaluation of the FleMatics module's effectiveness in promoting teacher engagement, student learning outcomes, and general educational quality within the context of secondary education through organised workshops and data-collecting processes.

Data Collection

Pre-survey and post-survey were distributed to the teachers 20 minutes before the workshop started and after five minutes, the workshop concluded. A five-point Likert scale was used in both questionnaires, where one indicated strongly disagree and five indicated strongly agree (Azman *et al*., 2021). This questionnaire was constructed in two sections: Demographic and perception questions from mathematics teachers regarding the use of a game-based learning approach and hands-on activities in mathematics classrooms. It also explores how this workshop helps them enhance their students' interest, specifically in mathematics subjects, to meet the goals of quality education.

The Statistical Package for the Social Sciences (SPSS) software was utilised to analyse all the data gathered throughout each stage and come to the study's conclusion. To determine the descriptive statistics, the dataset's central tendency (mean) and variation (standard deviation), a quantitative method was used to analyse the data.

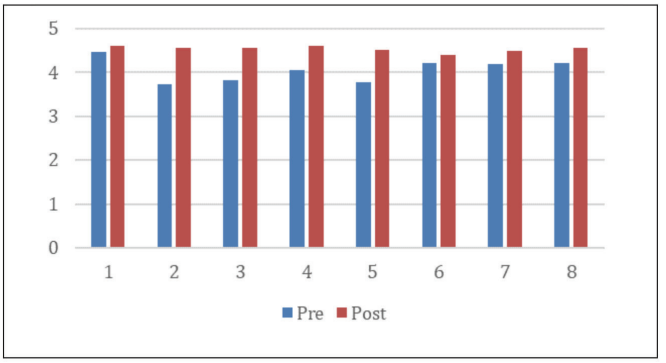
Results and Discussion

Petaling Jaya was chosen as the sample population for this study due to its socio-economic relevance and educational challenges. As part of the Petaling District, the area has a high concentration of B40 households, representing Malaysia's low-income group (Mayan & Nor, 2020). Students from this urban poor community often face academic struggles,

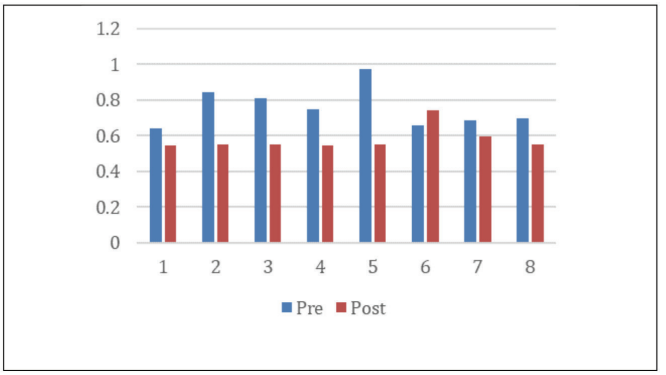
particularly in challenging subjects like mathematics, due to limited resources and low engagement with traditional learning methods. Past studies have shown that students from similar demographics tend to perform better on LOTS (Lower-Order Thinking Skills) questions, which involve remembering and understanding, compared to HOTS (Higher-Order Thinking Skills) questions, which require application, analysis, evaluation, and creation (Jamel & Nai, 2024). This underscores the importance of the game-based learning module introduced in this study, designed to address these educational gaps by fostering greater interest and engagement among students from vulnerable communities.

In this study, a FleMatics kit was developed to enhance students' interest in the mathematics subject through a game-based learning approach. This kit was named Fun Learning Mathematics to create a fun and interactive learning approach in mathematics lessons that can significantly increase students' interest in mathematics (Hamzah *et al*., 2019). The results from both the pre-survey and post-survey from the workshop are presented in Figure 1. Meanwhile, details for both mean and standard deviation are given in Table 1.

Based on Table 1, the mean value for a post-survey increases compared to the pre-survey. It is shown that mathematics teachers' perception increases towards the use of game-based learning approaches in their teaching and learning process. This increase means teachers agree that teaching design is an important element when teaching topics related to STEM subjects, specifically Mathematics. They also feel comfortable using this approach and believe that students learn STEM better through game-based learning, as compared to frontal teaching. Fun and interactive games can increase students'



(a)



(b)

Figure 1: Descriptive measures on mean (a) and standard deviation (b) for pre- and post-survey

Table 1: The results of the conducted pre- and post-surveys on teachers' perceptions towards game-based learning

		Pre-Assessment		Post-Assessment			
		Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***p*-value**	**Difference of Average Mean (post – pre)**
1	I believe that teaching design is an important element when teaching STEM subjects.	4.4750	.64001	4.6000	.54538	< 0.05	0.125
2	I incorporate game-based learning in some of my lessons.	3.7250	.84694	4.5500	.55238	< 0.05	0.825
3	I am comfortable using game-based learning in my lessons.	3.8250	.81296	4.5500	.55238	< 0.05	0.725
4	I believe that my students learn STEM better through game-based learning, as compared to frontal teaching.	4.0500	.74936	4.6000	.54538	< 0.05	0.5500
5	I believe that all STEM topics that I must teach can be taught through game-based learning.	3.7750	.97369	4.5250	.55412	< 0.05	0.7500
6	I believe that game-based learning in STEM lessons can help my students to think creatively.	4.2250	.65974	4.4000	.74421	< 0.05	0.1750
7	I believe that my students will be interested in learning STEM-based lessons through game-based learning.	4.2000	.68687	4.5000	.59914	< 0.05	0.3000
8	I believe that students will be motivated to learn STEM subjects when they can see a link between learning STEM and other subjects.	4.2250	.69752	4.5500	.55238	< 0.05	0.3250

interest and understanding of mathematics, interactive games can help students master mathematical concepts more efficiently (Hamzah *et al*., 2019). A *p*-value less than 0.05 means that there are significant differences in teachers' perceptions before and after the workshop session. Different studies assessing the effectiveness of fun learning modules have received similar positive outcomes on students' interest (Azman *et al*., 2021; Permanasari *et al*., 2024).

In this study, 75% of teachers agree that all STEM topics they teach can be taught through game-based learning and 30% of teachers agree that students will be interested in learning STEM-based lessons through game-based learning. By using game-based learning approaches, students engage in problem-solving to find solutions and earn marks when playing a game, which also involves teamwork skills. In another way, the interest and enthusiasm of students in learning mathematics are enhanced by using these approaches in the teaching and learning process (Ramli *et al*., 2020). This finding is consistent with our previous mathematical module, which integrated the elements of game-based and fun learning approaches (Hassan *et al*., 2021a; 2021b; Azman *et al*., 2022). All our previous studies portrayed significant interest and positive feedback among teachers and students when introduced to their respective mathematical modules.

This study explores teachers' perceptions of game-based learning strategies, focusing on changes after their introduction to the FleMatics kit. The findings demonstrate an increase in teachers' favourability toward game-based learning following the workshop, as reflected in the pre- and post-survey results in Table 1. These results can be contextualised using established educational theories such as the constructivist learning theory, self-determination theory, and inquiry-based learning. These theories offer insights into why game-based learning strategies effectively garner positive feedback from participants.

Game-based learning reflects constructivist principles by fostering a learning environment where students actively participate in problem-solving, self-directed learning, and collaboration (Ramli *et al*., 2020a; 2020b). Teachers take on the role of facilitators, guiding students to explore, experiment, discuss, and reflect rather than simply transmitting knowledge (Hanggara *et al*., 2023). The FleMatics Kit supports these principles by providing hands-on, interactive tools that encourage collaborative problem-solving and meaningful discussions, enhancing student engagement and interest in mathematics.

The survey results align with constructivist learning, as teachers reported increased confidence in using game-based learning (Pre: 3.8250, Post: 4.5500) and a stronger belief that it could improve student engagement and understanding (Pre: 4.0500, Post: 4.6000). These findings suggest that teachers recognise the potential of FleMatics in fostering active learning environments and student-centred instruction.

Whereas, self-determination theory emphasises intrinsic motivation by satisfying psychological needs for autonomy, competence, and relatedness (Supinah & Nuriadin, 2023). The FleMatics Kit was designed to promote independent learning, mastery of skills, and collaborative engagement, fostering motivation and a sense of achievement for both students and teachers.

The survey data support this connection, as teachers increasingly believed that game-based learning could make STEM topics more accessible (Pre: 3.7750, Post: 4.5250) and motivate students to learn when they see connections between STEM and other subjects (Pre: 4.2250, Post: 4.5500). Additionally, the rise in teachers incorporating game-based learning into their lessons (Pre: 3.7250, Post: 4.5500) suggests that they found it an effective and motivating instructional approach.

Additionally, inquiry-based learning encourages curiosity and critical thinking by presenting open-ended challenges that require students to ask questions, investigate solutions, and apply their knowledge in practical contexts (Hardman, 2019). The FleMatics Kit aligns with these principles by engaging students in hands-on exploration, problem-solving, and real-world applications of mathematical concepts.

Teachers' increased confidence in the belief that students learn STEM better through game-based learning (Pre: 4.0500, Post: 4.6000) and their view that it can help students think creatively (Pre: 4.2250, Post: 4.4000) further

reinforce this alignment. These results suggest that teachers see FleMatics as an effective tool for inquiry-based instruction that fosters deeper engagement with STEM concepts.

The alignment of the FleMatics Kit with constructivist learning theory, self-determination theory, and inquiry-based learning demonstrates its effectiveness in fostering sustainable quality education. The study highlights a positive shift in teachers' perceptions of game-based learning, showcasing its potential to transform classroom practices and outcomes while reinforcing the importance of student-centred, engaging educational strategies (Chiu, 2022). Table 2 shows the percentage of teachers who agree with the positive effect of workshop sharing on using game-based learning approaches in their teaching and learning process.

This study found that 97.5% of the teachers agree that workshops on game-based learning specifically for Mathematics subjects encourage them to foster their students' creativity. A teamwork activity inspired by game-based learning is a potential means of improving students' confidence and increasing their interest in learning (Gil-Doménech & Berbegal-Mirabent, 2019). Meanwhile, 92.5% of teachers agree that the approach shared in this workshop will motivate their students to learn Mathematics. This approach not only increases motivation and engagement but also promotes self-efficacy and positive attitudes towards the subject. These findings align with the goal of SDG 4, which aims to provide quality education by fostering a love for learning and ensuring inclusive and equitable access to education for all.

Besides, 97.5% of teachers also agree that this workshop provides ideas to present STEM content in ways to suit students' learning styles and 95.5% will recommend to other teachers how to apply STEM-based learning specifically in their lessons. Regarding the importance of in-depth knowledge of content, pedagogy, and game pedagogy, Boffa (2020) found that the effectiveness of mathematical games as a pedagogical tool varied, with some games showing lesser gains in learning compared to non-game activities.

Knowledge training and teaching practice during teacher education programs were positively related to STEM teachers' perceptions of their teaching competence while the level of knowledge, attitude, and self-efficacy of teachers toward teaching and learning STEM is influenced by their teaching experience (Song & Zhou, 2021). Another study stressed that trained teachers or experienced teachers have an impact on teachers' understanding, perspectives, and self-efficacy in STEM integration-based teaching and learning (Rasul *et al*., 2020). These results demonstrate that teachers valued the sharing workshop on the FleMatics module and STEM education in general, as well as the game-based learning strategies.

Table 2: Descriptive statistics of the workshop's effectiveness using game-based learning in the classroom

	Workshop's Effectiveness	Percentage (%)
1	This workshop provided me with ideas on how to foster creativity among my students.	97.5
2	I believe that the approach shared in this workshop will motivate my students to learn Mathematics.	92.5
3	I find this workshop useful in providing teaching strategies to teach STEM, especially Mathematics to my students.	95.0
4	This workshop provided me with ideas to present STEM content in ways that match the learning styles of my students.	97.5
5	I will recommend other teachers to learn about teaching STEM content through designing and making STEM-based activities.	95.5

During the post-mortem workshop, teachers provided valuable feedback based on their observations in the classroom as shown in Figure 2 below. They highlighted that students displayed a strong preference for hands-on activities, game-based learning, and project-based learning, as these approaches significantly enhanced engagement and active participation. Inquiry-based learning also emerged as an effective teaching method, with teachers noting that when students were encouraged to ask questions, explore problems, and arrive at solutions through guided discovery, they demonstrated notable improvements in critical thinking and problem-solving skills. This approach was particularly effective in fostering curiosity, independence, and deeper understanding, further enriching the overall learning experience (Hazim *et al*., 2024).

Specifically, teachers reported an interesting dynamic observed between two type of classroom groups, the front class (comprising higher-achieving students) and the back class (with students who typically exhibit less academic engagement). Students in the front class demonstrated a strong enthusiasm for project-based and inquiry-based learning, showcasing creativity, teamwork, and a deeper understanding of mathematical concepts through self-directed exploration. Similarly, students in the back class, despite their usual challenges in traditional instruction, displayed comparable passion and active involvement when engaging in both project-based and inquiry-based learning activities. For instance, these students showed greater motivation and confidence when allowed to investigate real-world problems and collaborate on group projects, highlighting the adaptability of these approaches to different learning levels (Ramli *et al*., 2020a).

These observations, rooted in direct classroom experiences, add an important layer of evidence to the study by demonstrating that innovative teaching methods like game-based, project-based, and inquiry-based learning not only resonate with teachers but also have a meaningful impact on student learning outcomes. This dual perspective strengthens the overall study and provides actionable insights for future iterations of the FleMatics program.

The findings from both Table 1 and Table 2 highlight the potential of game-based learning, especially with resources like FleMatics, to bolster SDG 4 for high-quality education. Interactive math activities cater to diverse learning styles, deepen understanding, and retain concepts, fostering enjoyment, critical thinking, and engagement. It promotes equality and inclusivity and develops essential 21st-century skills like creativity and problem-solving, crucial for success in today's world (Hui & Mahmud, 2023; Guan *et al*., 2024). Therefore, teachers

Teachers' Feedback During Post-mortem
When I applied this module in my class, students from the back row were very engaged and actively participated in group activities.
The workshop has opened my eyes to the possibilities of game-based learning as an effective teaching strategy.
The inquiry-based learning approach embedded in the kit encouraged my students to think critically and ask meaningful questions.
Game-based learning helped reduce classroom disruptions because the students were focused and engaged.
The inquiry-based learning approach embedded in the kit encouraged my students to think critically and ask meaningful questions.

Figure 2: Excerpt from teachers' feedback during post mortem. This excerpt has been translated and modified to enhance clarity

play a crucial role in advancing global education objectives and sustainable development by embracing game-based learning with innovative tools.

Conclusions

The study demonstrates a notable enthusiasm among teachers for game-based learning in mathematics education, specifically through the FleMatics module. Post-survey highlights the positive shift in teachers' perception towards game-based learning. The findings also indicate a strong consensus among participating teachers in Petaling Jaya, with up to 97.5% agreeing that game-based learning could nurture student creativity and motivation in mastering mathematical concepts. This suggests a significant potential for kits like FleMatics to positively influence both teaching practices and student engagement in mathematics classrooms.

As teachers increasingly adopt game-based learning strategies like FleMatics, students are likely to experience heightened enthusiasm and confidence in their mathematical learning journey. The interactive nature of these modules holds promise for improving students' problem-solving abilities and fostering collaboration, thus, enriching their overall learning experience. By equipping educators with innovative tools, the kit aligns with the Sustainable Development Goal (SDG 4): Ensuring inclusive and equitable quality education.

Future development of the Fun Learning Mathematics (FleMatics) Kit could focus on adapting it for resource-constrained environments by incorporating localised and simplified versions using affordable, reusable materials such as cardboard, recycled items, or hand-drawn elements. Low-cost alternatives such as printable worksheets and do-it-yourself assembly guides could enable wider adoption in schools with limited resources. A digital version optimised for low-end devices, accompanied by offline functionality could further improve accessibility.

Additionally, multilingual instructional guides and simple, adaptable lesson plans could help teachers integrate FleMatics effectively across different educational settings. Offering cost-effective online training and a collaborative platform for educators to share best practices could enhance scalability. By designing interchangeable components and flexible activities, the kit could be tailored to diverse learning needs, curricula, and contexts, extending its use beyond classrooms to community centres and extracurricular programs.

It is also essential to recognise the limitations of this study. The exclusive focus on teachers' perceptions restricts our understanding of direct student responses to FleMatics. Future research should incorporate direct measures of student learning such as pre-tests and post-tests to assess conceptual gains, classroom observations to evaluate engagement, or structured student feedback to capture their experiences. Additionally, the study's confined scope within Petaling Jaya may not fully represent broader educational contexts, particularly as urban teachers' perceptions and challenges may differ significantly from those of rural educators. Expanding the study to include a more diverse range of educational settings would provide a more comprehensive understanding of FleMatics' impact.

Despite these constraints, the study underscores the potential of game-based learning to advance STEM education and cultivate a proficient workforce, particularly in Mathematics. Investing in mathematics education not only enhances individual learning experiences but also contributes to the nation's progress in STEM disciplines. This emphasises the pivotal role of mathematics as a foundational element of a skilled workforce, crucial for propelling innovation and advancement in STEM fields.

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Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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