INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN PROGRESSIVE EDUCATION & DEVELOPMENT

OPEN ACCESS JOURNAL

Vol 12, Issue 4, (2023) E-ISSN: 2226-6348

Usability of Mathematics Gamification among Pre-Diploma Students

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To Link this Article: http://dx.doi.org/10.6007/IJARPED/v12-i4/19547 DOI:10.6007/IJARPED/v12-i4/19547

***Published Online*:** 15 November 2023

Abstract

Dedicated educators will constantly look for innovative approaches, such as gamification, to attract students' involvement in classrooms. Gamification is an enjoyable technique that effectively immerses students in academic learning, facilitating the development of critical learning and problem-solving skills, especially in Mathematics. To further investigate the effectiveness of gamification in learning, this study explored the usability of gamification on students in learning mathematics. A USE questionnaire was distributed to 30 pre-diploma students in Universiti Teknologi MARA (UiTM) after conducting several gamified learning sessions in a day. The gathered data was analysed using Spearman analysis. Findings reveal that Ease of Use and Satisfaction were significantly positively associated with the Usefulness of mathematics gamification. Thus, gamification helps enhance the quality of mathematics teaching compared to the traditional teaching approach alone.

Keywords: USE Questionnaire, Usability, Mathematics, Gamification, Pre-Diploma Students

Introduction

Most people perceive mathematics as a problematic topic requiring logical thinking and problem-solving abilities. Some students feel frightened, which could cause them to believe that mathematics is challenging. This study focused on pre-diploma students. This program is among UiTM's initiatives to assist students who have not yet fulfilled the requirements for a diploma program. For the students to be able to proceed to the diploma level, they must pass all of their courses, including the basic mathematics course (MAT037), during the program. A study by Mahlan et al (2023) found that the achievement of pre-diploma students recently was found to decrease when the online learning method was switched back to whole face-to-face learning after the pandemic COVID19. Addressing this problem is deemed imperative as it is feared that students' math performance will continue declining if it is not addressed.

As stated in the findings of Ting et al (2023), students tend to perform better in the MAT037 course when actively involved in the learning process. Therefore, to ensure the MAT037 course's success in the future, educators should encourage active learning and develop ways to involve their students in teaching and learning. Besides, other research also found that pre-diploma students were better in mathematics performance and helped to improve their interest in learning when lecturers used attractive ways of solving mathematical problems in

the classroom (Alam et al., 2021). The student's interest in mathematics courses also increased. Thus, a competent educator must take some action to spark students' interest in continuous learning.

Education is not just memorising facts to achieve good grades; students must also understand concepts and have critical thinking and problem-solving skills for a better quality of life. In the 21st century, gamification, such as Quizizz and Kahoot, has gained popularity as a learning tool to develop critical thinking and problem-solving skills and can increase student engagement in class (Kadri & Hayriman, 2021; Smiderle, 2020). Besides, several studies have found that gamification can effectively enhance the education process, such as in the aspect of motivation and performance (Alsadoon, 2023; Manzano-Leon et al., 2021; Kim & Castelli, 2021).

By transforming mathematics lessons into interactive games, mathematics gamification has been shown to encourage students to learn complicated mathematical concepts in a fun and exciting way (Abidin et al., 2019). This also includes raising academic achievement, enhancing problem-solving abilities, and stimulating interest in mathematics (Karamert & Kuyumcu Vardar, 2021; Lee et al., 2023; Sipin & Tan, 2023; Zainuddin et al., 2022). In the context of high school students, Rincon-Flores et al (2023) found that gamification through the use of a reward mechanism can improve their attitude in the aspect of increasing enjoyment and lessening anxiety toward mathematics. Additionally, Alt (2023) indicated that students' motivation and learning outcomes in mathematics could be boosted by gamification when it comes to the classroom. Therefore, this technique is advantageous to students.

Gamification in education is the application of game design features in a learning environment by educators (Blankman, 2022). Usually, the objective of the use is to improve learning engagement. Using the Google Trends website, a worldwide web search for "gamification in education" revealed a rising trend, as shown in Figure 1. In contrast, the second figure represents the web search interest based on the region. It proved that Malaysia ranked the second highest in exploring gamification in education. Both figures indicate that this study is relevant, and the author expresses the hope that it will provide valuable insights and encourage educators to implement gamification more effectively.

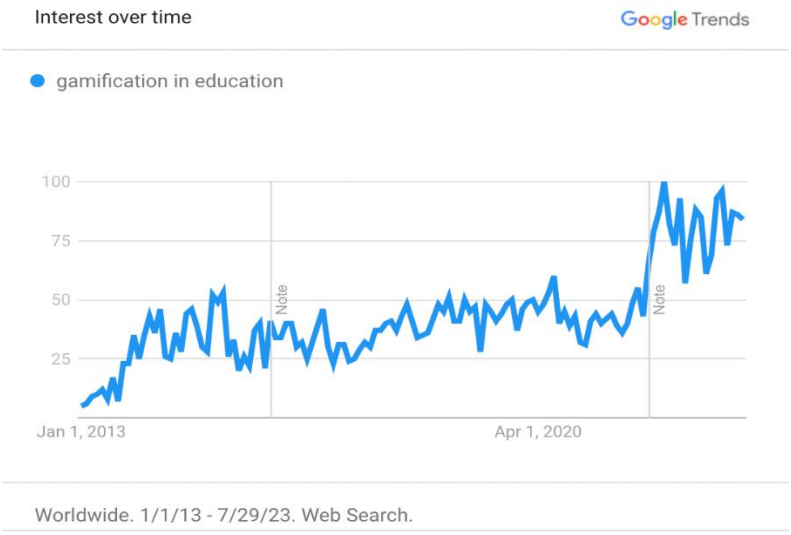

Figure 1. The popularity in web searches for the past ten years up to 2023

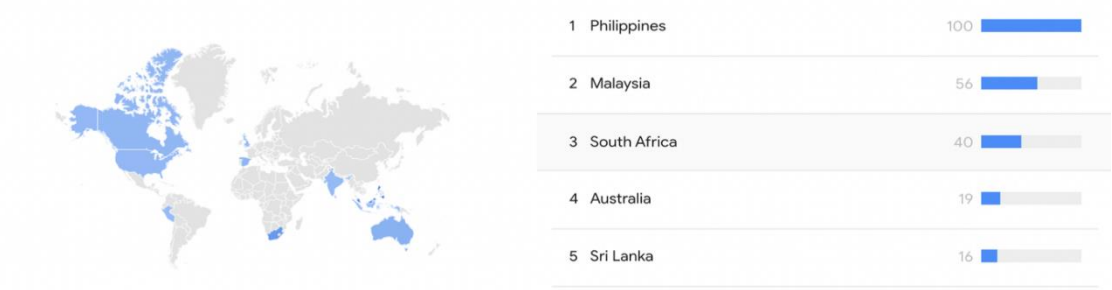

Figure 2. The popularity of web searches according to the region (January 2013 - July 2023)

Theoretical Foundations

Most studies determine the perception of gamification, with fewer studies investigating its usability of gamification in the learning process, specifically for mathematics. For this study, the USE questionnaire developed by Lund (2001) has been applied to measure the usability of gamification in the learning process for mathematics courses. There are four usability dimensions: Usefulness, Satisfaction, Ease of Learning, and Ease of Use. (1) Usefulness is targeted to identify whether gamification can improve learning productivity and performance in mathematics courses. (2) Ease of Use is applied to know whether the gamification is simple and easy to play. At the same time, (3) Ease of Learning is used to measure the speed of understanding of new users in mastering gamification. Lastly, the Satisfaction dimension is concerned with measuring respondents' emotional response toward mathematics gamification. A conceptual framework to explore the relationship between variables for this study is shown in Figure 3.

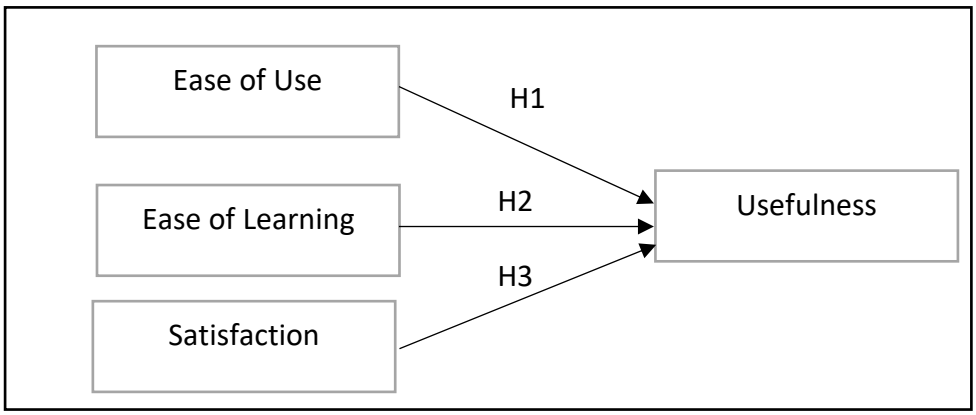

Figure 3. Conceptual framework and hypotheses

The following shows the hypotheses derived from the conceptual framework

H1: A positive significant association exists between Ease of Use and Usefulness of using mathematics gamification.

H2: A positive significant association exists between Ease of Learning and Usefulness of using mathematics gamification.

H3: A positive significant association exists between Satisfaction and Usefulness of using mathematics gamification.

Methodology

The data for the study was collected from pre-diploma students at Universiti Teknologi MARA (UiTM) Mukah Campus whose taking MAT037 (Intensive Mathematics I course) for the semester of March until July 2023. There were 35 students taking the code for that semester; however, only 30 students participated in one-day gamified Mathematics learning sessions. The gamification comprises several different topics, which are (1) Arithmetic, (2) Algebra, (3) Equations, (4) Functions, and (4) Index. Therefore, all the students who participated in the gamification were respondents to this study. The students were generally between the age of 17 to 18 years old.

After participating in the learning session using gamification, an electronic questionnaire containing 23 questions (including a demographic profile) was distributed among respondents. The questions for Likert Scale were adapted from Lund (2001) using a 7-point scale ranging from "1" strongly disagree to "7" strongly agree. There were originally 30 items from Lund (2001), but 9 items were found to be irrelevant and were not included in the study. The table below shows the number of items according to the amended USE questionnaire.

Table 1
Number of Items for the Study Dimensions

Dimension	Usefulness	Ease of Use	Ease of Learning	Satisfaction
No. of Items	4	8	4	5

Descriptive statistical analysis was used to determine the percentage and frequency of students' profiles (gender and program) and agreement in the aspect of usability, ease of use, ease of learning, and satisfaction with the gamification. In order to analyze the strength and direction of the association between the variables, a non-parametric test called Spearman Rank-Order Correlation was used since the sample size was small and the variables were ordinal categorical in nature. The null hypothesis will be rejected if the p-value is less than 0.05 in this study.

Findings

The study comprised a total of 30 respondents participated, of whom 53.3% (16 respondents) were females and 46.7% (14 respondents) were males. The figure below shows the distribution of gender according to the program code of students taken. It shows that most respondents were those taking a Pre-Diploma in Commerce, with 25 respondents or 83.3%, while the remaining were taking Pre Diploma in Agrotechnology (5 respondents or 16.7%).

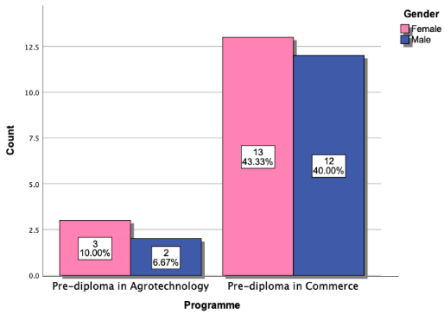

Figure 4. A multiple bar chart of gender distribution across programs

Table 2 presents the frequency and percentage for each item of the USE questionnaire. A scale of 7 (strongly agree), a scale of 6 (agree), and a scale of 5 (somewhat agree) categorized as agreeing with the statements; in contrast, the rest scales, which are 4 (neither agree nor disagree), 3 (somewhat disagree), 2 (disagree) and 1 (strongly disagree) categorized as not agree. The noticeable from the four items under the Usefulness variable, more than 80% of the respondents agreed that gamification positively contributes to their mathematical performance. This finding presents a positive sign that gamification should be introduced to all educators.

Meanwhile, the overall Ease of Use variable revealed that over 60% of the respondents had a positive view that gamification requires less effort and is easy to handle. However, about 36.6% of the respondents disagreed that gamification is easy to play. Besides, nearly half of the respondents (46.7%) agreed that gamification must have explicit instructions, and 40% found contradictions during playing. For this reason, educators must ensure that gamification is easy to access, provides clear instructions, and maintains simplicity to facilitate effective learning and enhance students' enjoyment of the learning experience.
Over 75% of respondents believed learning how to play the game was easy, as indicated in the Ease of Learning variable results. Based on the positive responses from the majority of respondents to the study, the gamification approach used in this study was simple to understand, and they quickly became proficient at using it.

In the meantime, the descriptive findings for the Satisfaction variable proved that most respondents were satisfied with the gamification and would recommend it to their friend, with a percentage of agreeing more than 80%. This shows that the gamification approach successfully grabbed students' interest and created good learning experiences for them.

Table 2
Respondents' Perception of the Usability of the Mathematics Gamification

USE Framework	**Frequency (Percentage)**						
Usefulness	1	2	3	4	5	6	7
1) It helps me improve my performance in mathematics.	1 (3.3%)	1 (3.3%)	1 (3.3%)	2 (6.7%)	1 (3.3%)	21 (70.0%)	3 (10.0%)
2) It helps me increase my learning productivity in mathematics.	1 (3.3%)	1 (3.3%)	1 (3.3%)	1 (3.3%)	2 (6.7%)	20 (66.7%)	4 (13.3%)
3) It helps me enhance my effectiveness in mathematics.	1 (3.3%)	2 (6.7%)	0 (0.0%)	1 (3.3%)	2 (6.7%)	21 (70.0%)	3 (10.0%)
4) It helps me to achieve a better grade in mathematics.	1 (3.3%)	1 (3.3%)	1 (3.3%)	1 (3.3%)	2 (6.7%)	21 (70.0%)	3 (10.0%)
Ease of Use							
1) It is easy to use/play.	1 (3.3%)	1 (3.3%)	4 (13.3%)	5 (16.7%)	5 (16.7%)	12 (40.0%)	2 (6.7%)
2) It is simple (not complicated) to use/play.	1 (3.3%)	1 (3.3%)	3 (10.0%)	6 (20.0%)	2 (6.7%)	16 (53.3%)	1 (3.3%)
3) It requires the fewest steps possible to accomplish what I want to do with it.	1 (3.3%)	0 (0.0%)	3 (10.0%)	6 (20.0%)	3 (10.0%)	16 (53.3%)	1 (3.3%)
4) Using it is effortless.	0 (0.0%)	0 (0.0%)	5 (16.7%)	5 (16.7%)	5 (16.7%)	12 (20.0%)	3 (10.0%)
5) I know to use/play it without written instructions.	2 (6.7%)	3 (10.0%)	2 (6.7%)	7 (23.3%)	4 (13.3%)	11 (36.7%)	1 (3.3%)
6) I can recover from mistakes quickly and easily.	1 (3.3%)	1 (3.3%)	2 (6.7%)	6 (20.0%)	4 (13.3%)	13 (43.3%)	3 (10.0%)
7) I can use/play it successfully every time.	1 (3.3%)	2 (6.7%)	0 (0.0%)	7 (23.3%)	3 (10.0%)	14 (46.7%)	3 (10.0%)

8) I don't notice any inconsistencies as I use/play it.	1 (3.3%)	2 (6.7%)	1 (3.3%)	8 (26.7%)	2 (6.7%)	13 (43.3%)	3 (10.0%)
Ease of Learning							
1) I learned to use/play it quickly.	1 (3.3%)	0 (0.0%)	0 (0.0%)	5 (16.7%)	6 (20.0%)	16 (53.3%)	2 (6.7%)
2) I easily remember how to use/play it.	1 (3.3%)	0 (0.0%)	1 (3.3%)	5 (16.7%)	7 (23.3%)	14 (46.7%)	2 (6.7%)
3) It is easy to learn to use/play it.	1 (3.3%)	1 (3.3%)	0 (0.0%)	5 (16.7%)	5 (16.7%)	16 (53.3%)	2 (6.7%)
4) I quickly became skilful with it.	1 (3.3%)	1 (3.3%)	0 (0.0%)	5 (16.7%)	4 (13.3%)	15 (50.0%)	4 (13.3%)
Satisfaction							
1) I am satisfied with it.	1 (3.3%)	0 (0.0%)	0 (0.0%)	3 (10.0%)	5 (16.7%)	15 (50.0%)	6 (20.0%)
2) I would recommend it to a friend.	1 (3.3%)	0 (0.0%)	0 (0.0%)	2 (6.7%)	6 (20.0%)	17 (56.7%)	4 (13.3%)
3) It is fun to use/play.	1 (3.3%)	0 (0.0%)	0 (0.0%)	3 (10.0%)	7 (23.3%)	15 (50.0%)	4 (13.3%)
4) It is wonderful.	1 (3.3%)	0 (0.0%)	0 (0.0%)	3 (10.0%)	7 (23.3%)	15 (50.0%)	4 (13.3%)
5) It is pleasant to use/play.	1 (3.3%)	0 (0.0%)	0 (0.0%)	3 (10.0%)	6 (20.0%)	16 (53.3%)	4 (13.3%)

Spearman's rank correlation results (Table 3) showed a moderately positive association between Usefulness and Ease of Use, $r(28) = .457$, $p = .011$. Moreover, a moderate positive association was also found between Usefulness and Satisfaction, $r(28) = .430$, $p = .018$. However, Usefulness is not significantly associated with Ease of Learning, $p = .091$. Therefore, this study accepted only two hypotheses (H1 and H3) based on the correlation results.

From these results, it also shows that there is a significant association between Ease of Use and Ease of Learning ($r = .603$, $p < .01$); Ease of Use and Satisfaction ($r = .634$, $p < .01$); Ease of Learning and Satisfaction ($r = .646$, $p < .01$). These associations might indicate a mediating or moderating association among variables. However, this study did not analyze the effect.

Table 3
Results of Spearman's Rank Correlation Analysis

Variables	1	2	3
(1) Usefulness			
(2) Ease of Use	.457*		
(3) Ease of Learning	.314	.603**	
(4) Satisfaction	.430*	.634**	.646**

*p<.05, **p<.01

Conclusion

In this study, the author tested the relation of ease of use, ease of learning, and satisfaction in using mathematics gamification among pre-diploma students. Overall, most students gave positive feedback on the gamification as a learning session. Most respondents agreed that the gamification was easy to learn and use. Besides, they expressed satisfaction with the experience, even recommending it to their friends. In addition, they believe that the use of gamification can enhance their performance and learning efficiency in mathematics courses. However, Ease of Use and Satisfaction with gamification significantly affected the Usefulness of mathematics gamification in learning arithmetic, algebra, equations, functions, and indexes. Indeed, it is essential to note how easy it is to use and how satisfied students are

with gamification plays a vital role in determining the usefulness of gamification in learning mathematics.

Therefore, educators should implement gamification as one of the learning sessions to enhance students' motivation and efficiency in learning mathematics. Gamification may enhance lesson plans and help students get the most out of class time, whether inside or outside the classroom. By constantly challenging students and finding new learning opportunities for them to explore, like gamification, educators can help students improve their understanding of learning and refine problem-solving skills. Nonetheless, mathematics gamification might require modifications, such as clear game instructions, to enhance its usability and heighten users' comfort. Furthermore, when educators use gamification techniques as part of the education process, they should ensure that the gamification is as easy as possible and enjoyable for students.

The study's limitation lies in its focus on students at the UiTM Mukah Campus. In order to more generally generalise the results, the author suggests that future research consider an enormous number of samples. Also, the author suggests further assessing the association between independent variables and adding the variable of mathematical performance to evaluate the impact of gamification usability on the use of gamification.

Acknowledgement
The author would like to thank the pre-diploma UiTM Sarawak Branch students from the Mukah Campus who responded to the questionnaire of this study.

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