

“Calcu-Less Craze”: An Online Gamified Approach to Mathematics Learning

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Abstract: *This research explores the efficacy of an online mathematics game as a tool to enhance learning outcomes in mathematical education. The game, designed to leverage the interactive and immersive nature of online gaming, offers a dynamic platform for learners to engage with mathematical concepts in a playful and stimulating environment. Therefore, an educational online game for Calculus has been developed called as “Calcu-less Craze” which focuses on differentiation and integration topics. This study aims to examine the impact of online game-based learning activities on the students’ perceptions towards Calculus subject. A sample of 100 students taking Mathematics 3 (MAT0134) from CFS IIUM has been selected for this pilot study using purposive sampling technique. SPSS 28.0 was used to analyze the data using both descriptive and inferential statistics. The result suggested that students playing “Calcu-less Craze” may enhance their learning in mathematics. In summary, the transformative potential of an online mathematics game as a catalyst for enhancing learning experiences and outcomes in mathematical education. This opens the door for creative methods to teaching and learning in the digital age.*

Keywords: Online Mathematics Game, Differentiation, Integration, Calculus

1. Introduction

In the past, one of the toughest subjects for students was always mathematics. This subject can be categorized as one of the unique disciplines which encourages and supports critical thinking among students. Lecturers traditionally will teach students in a certain way and students come to class. It is stated that today’s world is incredibly mathematical; therefore, it is imperative that contemporary citizens be aware of it (Arseven, 2015; AllAfrica, 2011). Since mathematics is vital in today’s world, effective mathematics instruction is given a lot of focus at all educational levels. According to Nicola (2018), despite being aware of the importance of mathematics, many students nowadays have shown and stated how much they dislike it. Another issue raised by the researchers is that students frequently lack interest in mathematics classes because the subject matter is vague and abstract as mentioned by (Mutlu, 2019; Re et al., 2020). A simple mathematical explanation of the concept will be an oversized hurdle for those students who need a fundamental understanding. Calculus is considered as one of the hard-to-understand subjects in upper levels. This makes it a challenging material so that the lecturers always require many efforts to deliver lessons perfectly, (Solekhah, Kutni, & Pamungkas, 2023). As a result, educators were encouraged to use digital technologies as

pedagogical aids in their lessons. Instructors can improve the students' academic performance by gamifying their lesson with digital technologies.

The use of gamification in the subject mathematics is a way to motivate students to take interest in mathematical subjects, (Sánchez-Martín et al., 2020; Suárez-López et al., 2023). Game-based learning procedures utilize game mechanics and game style strategies to energize assignments by understudies, like tackling tasks as mentioned by (Sánchez-Martín et al., 2020). Meanwhile, it is highlighted that gamification or game-based learning is an intriguing method of teaching and learning mathematics which aims to make learning more enjoyable and engaging, (Doan, 2018). For the gamified activity, as it is mentioned in (Sánchez-Martín et al., 2020), this has led students to an increase on learning. It is also stated that gamification has increased the students' interest in engineering without requiring extra effort. Furthermore, based on Pontes et al. (2020) and Zumbach et al. Game-based learning techniques have drawn the interest of numerous studies due to their effectiveness as teaching tools that encourage and engage students while improving their academic performance based on (Zumbach, Rammerstorfer, & Deibl, 2020). According to Sintian et al. It has been shown that by using digital technology, students become more confident and skilled in their understanding of complex mathematical concepts, (Sintian, Kiting, & Wilson, 2021). Therefore, this study was conducted to learn about the effectiveness of gamification on students' mathematical learning abilities especially in calculus subject during classroom practices at Centre for Foundation Studies, International Islamic University Malaysia, CFS IIUM Gombang.

For many years, mathematics has been one of the subjects that give challenges for learners at all levels of education. It gives challenges to the lecturers to ensure that they can deliver and teach this subject successfully, (Solekhah, Kutni, & Pamungkas, 2023). This subject requires understanding of the concept and basic algebra. In CFS IIUM level, Calculus is one of the subjects offered to all Physical Module Sciences students. Many approaches have been practiced by lecturers to give their best to students so that they easily understand this subject. Traditional teaching techniques, based on notes and exercises, might be difficult to catch the students' interest. As a result, many students need help to better understand the subject before they lack motivation and have poor performance in this subject. The problem of students' motivation and disengagement in calculus needs additional teaching approaches that increase students' motivation and always feel that the game is effective and engaging when learning this subject. In the other hand, in education, students enjoy receiving rewards from their lecturers or teachers. Refer to (Solekhah, Kutni, & Pamungkas, 2023), giving rewards may boost students' involvement with this challenging subject. As a result, in this study, the game which is known as "Calcu-less Craze" has been created to help students learn calculus more effectively because it offers different level of obstacles and at the same time, they enjoy collecting points

This paper will focus on three main objectives that are to cultivate critical thinking and problem-solving abilities to understand mathematics course. Furthermore, is to increase students' self-confidence, especially when they manage to overcome obstacles and succeed in answering all the questions provided in the game. Lastly, to investigate the impact of online game-based learning activities on the students' perceptions towards Calculus subject in terms of their motivation for learning, the effectiveness of gamification and their engagement to calculus topics.

2. Methodology

Innovation: Calcu-Less Craze Online Game

The game's idea is to help the students enhance their calculus skills on the topic of differentiation and integration through interactive learning. The Calcu-Less Craze game was created using Buildbox software, which is free software that provides all the tools needed to complete the game creation by connecting the mind map in the software and does not require coding or programming language. The software also enables gaming experiences using devices such as laptops and smartphones.



Figure 1: Calcu-Less Craze Starting Game User Interface

The main character chosen in this game is a cat character named Mr. AliCat. The character was created to have animations of walking, jumping, shooting, and dead. The idea of choosing a cat is because, with all the viral memes all about cats, it will attract the students to play and enjoy playing the Calcu-Less Craze game.



Figure 2: The Main Character Mr.Alicat Animations

The game was designed so that Mr. AliCat must go through four stages of adventure. The first stage was the demonstration level, and the remaining 3 stages were 3 levels with 10 calculus questions on the topic of differentiation and integration. The demonstration level was created to help players familiarise themselves with how the buttons and the flow of the game work. The 3 levels are Level 1: Easy Questions, Level 2: Moderate Questions, and Level 3: Hard Questions. The adventure of the game was that Mr. AliCat had to collect scores and points. Scores were given when Mr. AliCat collected superfoods, which are fish and drumsticks, and points were given when the player answered the calculus questions correctly. Mr. Alicat needs to find Mr. Khawarizmi to answer the pop-up questions.

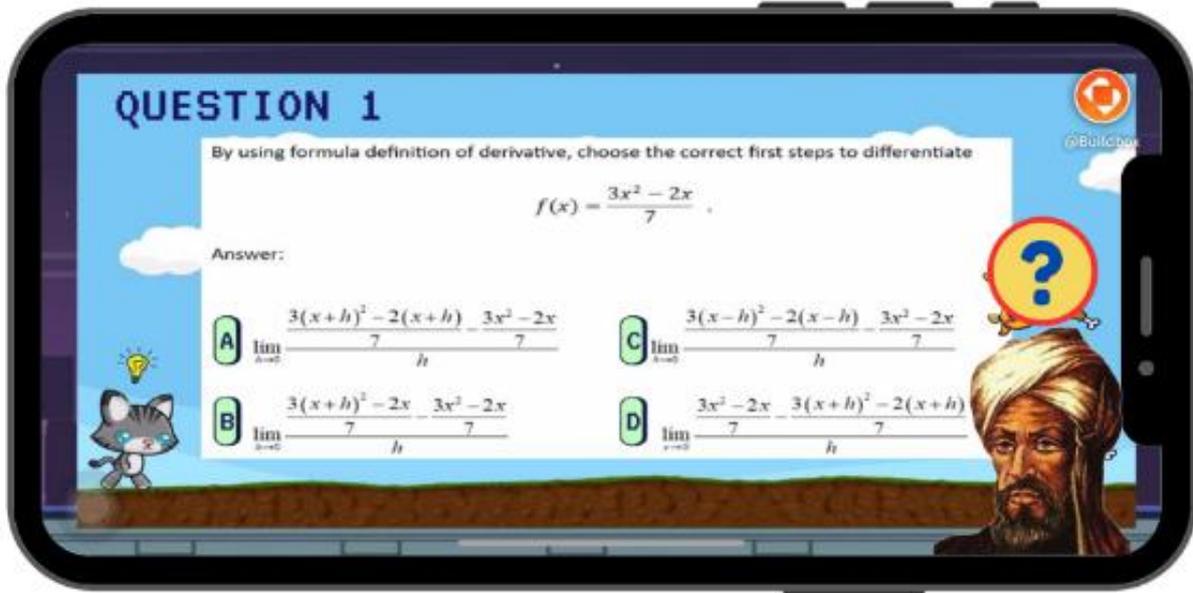


Figure 3: Example Of Mr.Alicat Meeting Mr. Khawarizmi To Answer Questions

When a player answered the question correctly, ten points were given and the game adventure will continue; if a player answered incorrectly, popout information and tips on how to answer the question correctly were provided so that the students can learn from their mistakes. The player can then carry on with the game's adventure.

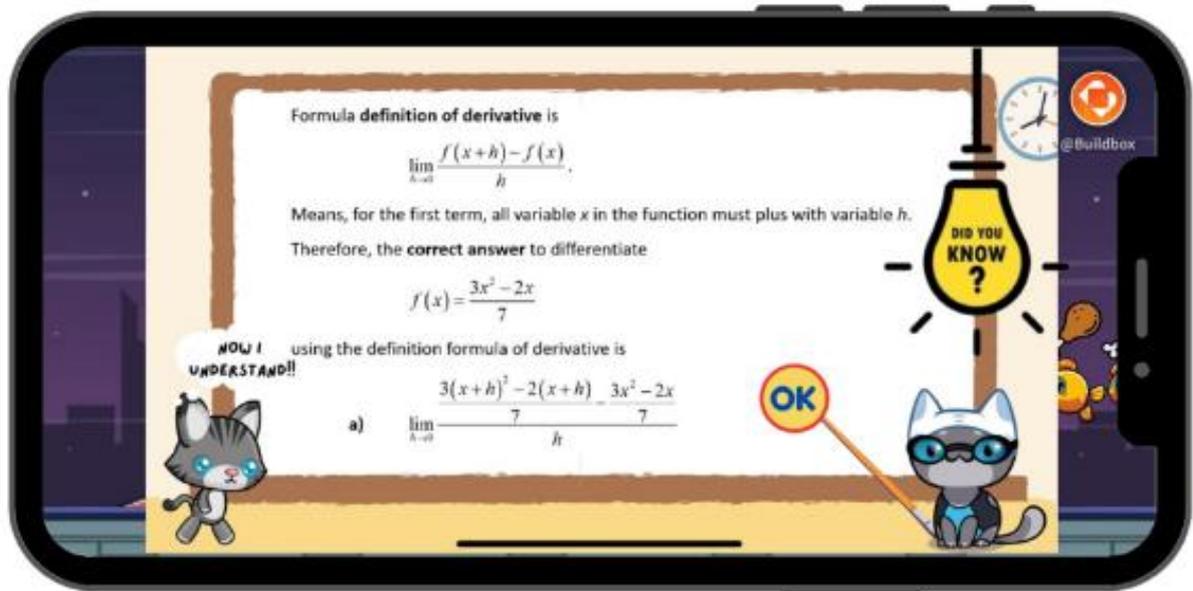


Figure 4: Example of Information Given For Wrong Answer

Adding to the adventure of Mr. Alicat, obstacles were created by adding enemies such as Raging Rats, Red Guradian dog, and the Moving Monster. Besides that, there were platforms that Mr. AliCat needed to avoid, such as thorny platforms, icy water platforms, and moving blocks. Mr. AliCat needs to avoid the obstacles by jumping into assistance platforms or shoots the enemies. In some scenes, a bomb was used to kill the rush of enemies that attacked Mr. Alicat. Last but not least, there were further cautions about the hazards that Mr. AliCat needs to avoid integrating with calculus themes.



Figure 5: Example of Obstacles

Population & Sample

This study was conducted with students to gain feedback on the Calcu-Less Craze game. The population of study includes students from Engineering and Physical modules in the Centre for Foundation Studies (CFS) at the International Islamic University Malaysia (IIUM) of the Gambang campus. Purposive sampling was used, and a sample of 103 students taking Mathematics 3 in semester 3 session 2023/2024 was chosen for this study. The data analysis will be divided into two parts, which are descriptive and inferential. The descriptive part will be using the measure of central tendency, and the inferential part will be using the Mann-Whitney U Test and Kruskal-Wallis Test.

Data Collection

In order to get feedback for Calcu-Less Craze game, a set of questionnaires was developed. The questions were adapted by Yildirim (2017) and Chan and Lo (2022). There are three main constructs used in this study which are motivation for learning (4 items), effectiveness of gamification (4 items) and engagement (3 items). All the 11 items were evaluated using a 7-point scale which went from 1 (strongly disagree) to 7 (strongly agree). The questionnaires were given to the students immediately after they played the Calcu-Less Craze game. All the collected data was then analysed by using SPSS 28.0 for both descriptive and inferential statistics.

3. Results and Discussions

Demographic

In this study, the population was CFS IIUM students who took MAT0134 in Semester 3, 2023/2024. A sample of 103 students was taken using the purposive sampling method. The percentages based on gender was 31% (32 students) female students and 69% (71 students) male students, as demonstrated in Figure 6.

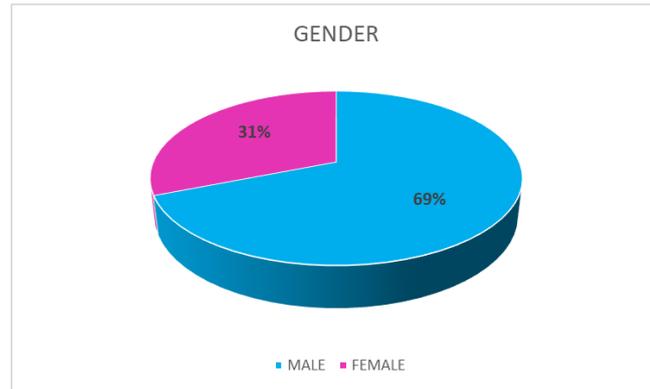


Figure 6: Gender

As we can refer to Figure 10, the sample was divided into four levels of CGPA which were High (CGPA 3.50 - CGPA 4.00), Average (CGPA 3.00 - CGPA 3.49), Low (CGPA 2.50 - CGPA 2.99) and Very Low (CGPA 2.00 - CGPA 2.49).

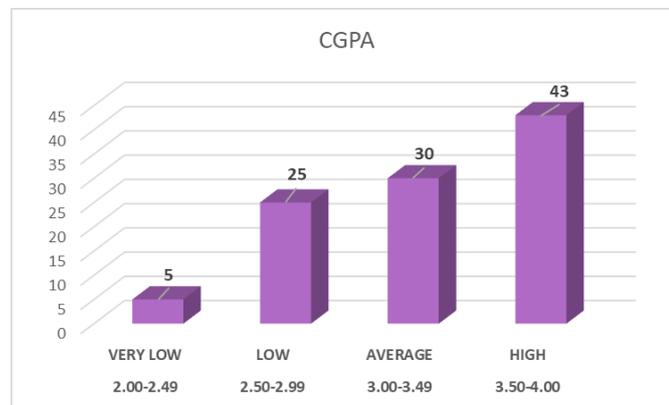


Figure 7: CGPA

Survey on Students' Perception of Calcu-Less Craze Game.

The survey form was administered to the students after they played the game to gain their perceptions as objectively as possible. The internal consistency of the item was tested using Cronbach's alpha for all three constructs. Table 1 below showed that the value of the Cronbach's alpha is in between 0.8 to 0.9 which indicates that the items were reliable and consistent to be applied to the respondents. Cronbach's alpha is the most used to measure the reliability of the instrument. The commonly accepted rule for evaluating internal consistency using Cronbach's alpha can be found in Table 1.

Table 1: Cronbach's Alpha Level Of Reliability.

Cronbach's Alpha Score	Interpretation
0.00-0.20	Less reliable
>0.20-0.40	Rather reliable
>0.40-0.60	Quite reliable
>0.60-0.80	Reliable
>0.80-1.00	Very reliable

Using reliability test, the Cronbach's alpha coefficient for construct motivation for learning, effectiveness of gamification and engagement were found to be 0.896, 0.897 and 0.902 respectively as shown in Table 2. These values showed that the items in the survey were adequate, having high internal consistency and very reliable for carrying out this research.

Table 2: Reliability of The Questionnaire

Construct	No. of item	Cronbach's alpha value
Motivation for learning	4	0.896
Effectiveness of gamification	4	0.897
Engagement	3	0.902

Descriptive Analysis

In the descriptive analysis, the mean scores for each construct were displayed in Table 3. The outputs from a survey using questionnaires with 7-point scale showed that the mean scores were 6.09 for Motivation, 6.12 for Effectiveness and 6.24 for Engagement. The standard deviation was 0.91 and 0.97 which demonstrated low variability of the data distribution and the data is tightly clustered. Hence, it is concluded that the students agreed that the Calcu-Less Craze game had highly impact on their motivation in learning calculus, effectively helped the students in understanding the topics and build positive engagement with the gamification in learning.

Table 3: Mean And Standard Deviation For Each Construct.

Students' Perception	N	Item	Mean	Average Mean	Standard deviation
Motivation for learning	103	ML1	6.05	6.09	0.91
		ML2	6.05		
		ML3	6.24		
		ML4	6.04		
Effectiveness of gamification	103	EF1	6.16	6.12	0.91
		EF2	6.13		
		EF3	6.12		
		EF4	6.11		
Engagement	103	ENG1	6.18	6.24	0.97
		ENG2	6.21		
		ENG3	6.33		

The students' feedback is shown in Figure 8 according to certain items. The scores considered agree start from score 5, 6 and 7. For example, 95.10% of the students agreed with the item "I am excited when successfully choose the correct answer for the questions in Calcu-Less Craze game." Next is the item "Calcu-Less Craze makes me understand the topic better" are agreed by 94.20% of the students.

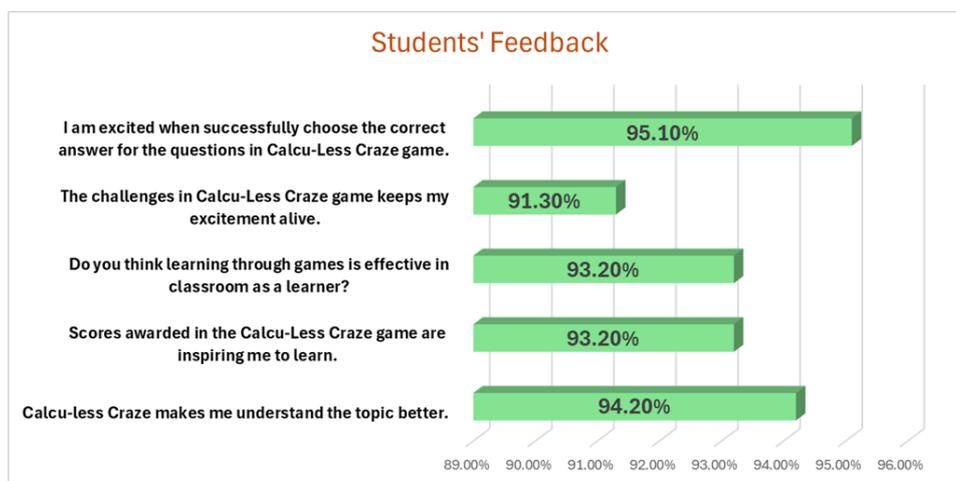


Figure 8: Students' Feedback on Calcu-Less Craze Game

Inferential Analysis

The normality test was run on the mean scores of each construct, and it was found that the Kolmogorov-Smirnov p-value was <0.001 . Thus, the data was not normally distributed, and a nonparametric test will be used to compare the distributions between gender. Based on Ai, Huang, and Zhang (2020), a Mann-Whitney test was efficient in comparing the two outcomes from the population. Thus, analysis was done using Mann-Whitney U Test to compare the students' perceptions in term of motivation for learning, effectiveness of gamification and engagement between male and female students.

HO₁: There is no significant difference in students' perception among gender.

Based on Table 4, it shows that at the 5% significance level, there is no significant difference of the students' perceptions across gender since the p-value is 0.096 which is more than 0.05. It reflects that there is no statistically meaningful variation in how male and female students perceive the game-based learning. This finding contradicts with the research by Hartmann and Klimmt (2006) where they found that female students are less likely to participate in competitive online games than male students. In addition, Dabraj (2009) stated that female students in digital environments had a better perspective than male students. Seaborn and Fels (2015) argued that female students are more attracted by badges in gamification than male students.

Table 4: Independent-Samples Mann-Whitney U Test for Students' Perception Across Gender

	GENDER	N	Asymp. Sig. (2-tailed)
STUDENTS' PERCEPTION	Male	71	0.096
	Female	32	

The significance level is .050.

HO₂: There is no significant difference for all construct (motivation for learning, effectiveness of gamification and engagement) across CGPA.

Kruskal-Wallis's test was done to determine if there were significant difference between all constructs across CGPA. As displayed in Figure 7, the students were categorized into high, average, low and very low categories.

Table 5: The P-Values of Kruskal-Wallis Test

CGPA	N	MOTIVATION	EFFECTIVENESS	ENGAGEMENT
High	43			
Average	28			
Low	25	0.558	0.354	0.819
Very low	5			

Based on Table 5, the p-values for construct motivation for learning, effectiveness of gamification and engagement were 0.558, 0.354 and 0.819 respectively where all the values more than 0.05. Therefore, at 5% significance level, there is no significant difference between the distributions of each construct across CGPA. It means that the students CGPA level is not affected by their perceptions on gamification. As from past study by Abubakar et al. (2021), there were no association between students' CGPA level and their perseverance of effort from the students' perceptions.

4. Conclusion

Applying online games in education shown highly potential as an effective tool to improve education systems since it combined entertainments and knowledge in one platform. It is in line with the current technology development in teaching and learning process.

Developing “Calcu-Less Craze” game as an alternative tool in teaching Mathematics 3 in CFS give positive impact to the students. They agree that this method can make them excited in learning calculus, make them interested in learning process and they can understand the topic better. In addition, this game gives immediate feedback to them which indirectly create self-learning environment.

Moreover, “Calcu-Less Craze” game also shown the positive feedback towards student perspectives in motivation, effectiveness and also engagement towards calculus subject. It also proves that this game is suitable to be played by any gender and it is not discriminate the students by their achievement level.

In summary, when incorporated online games in teaching and learning, it can be a very powerful tools to improve learning process, helping students in develop their thinking abilities and in the same time it makes the study process fun and exciting.

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