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COMPARISON OF STUDENT ACHIEVEMENT THROUGH CIRCUMFERENCE BOARD GAMIFICATION BETWEEN SCHOOLS IN PUTRAJAYA

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ABSTRACT

This study aims to evaluate the impact of Circumference Board gamification on the achievement of second-form students in the topic of circles at two schools in Putrajaya, Malaysia. The study involved 60 students, with 30 students from each school (15 male and 15 female) selected using random stratified sampling. A quasi-experimental design was employed, utilizing a quantitative approach with pre- and post-test instruments to measure students' academic performance. Data analysis included a dependent t-test to assess changes in student achievement and an independent t-test to examine potential gender differences in achievement. The findings reveal a significant improvement in student performance after engaging with Circumference Board gamification, with a p-value of <0.05 indicating no significant gender differences in achievement, thereby supporting the null hypothesis (Ho2). This study concludes that Circumference Board gamification enhances students' understanding of circles and impacts their achievement positively, regardless of gender. Future research could broaden the sample to enhance the generalizability of the results and incorporate additional demographic variables for deeper insights. Additionally, integrating international perspectives on gamification in education could strengthen the theoretical foundation of the study.

Keywords: *Gamification, circle, mathematics education, pre-test, post-test.*

INTRODUCTION

The 21st-century learning (PAK21) has become one of the most prominent educational phenomena in Malaysia today. PAK21 is an effective approach that aligns with the era of globalization, aiming to produce a skilled and competent generation. The Malaysian Education Blueprint (PPPM 2013-2025) outlines six key student aspirations that must be achieved: communication, collaboration, critical thinking, creativity, and the application of noble values and ethics (Wardywaty & Mohd Isa, 2020). The teaching and learning (TnL) process in classrooms serves as the primary platform for implementing this policy, with teachers utilizing a variety of methods to facilitate student development. As such, the role of teachers in applying PAK21 has become crucial in building a generation prepared to face global challenges (Nor Atika & Siew, 2022).

To thrive in the 21st-century learning environment, mathematics teachers must find innovative approaches that equip Generation Z to confront the challenges of the 4th Industrial Revolution while maintaining strong spiritual values, personal characteristics, and a national identity. In this context, the Circumference Board emerges as an alternative tool that supports the achievement of PAK21's aspirations, particularly in mathematics education.

Teaching and learning in the 21st century must align with advancements in technology. Gamification, or game-based learning, can make the TnL process more interactive and enjoyable (Kitikedizah &

Maimun Aqsha, 2022). In gamification, systems are designed to support individual and collaborative learning, manage learning content and activities, and bridge both formal and informal learning environments (Yaniaja et al., 2021). Students who engage in gamification develop strong problem-solving skills and are actively involved in reflective learning, which promotes deeper understanding (Nivandi et al., 2022). By integrating gamification, educators can equip students with skills relevant to contemporary challenges (Muhammad Ammar & Asdar, 2022). The use of gamification in education offers numerous benefits, including more engaging and interactive lessons, increased student motivation, and the ability for students to identify their strengths and weaknesses, ultimately leading to improved achievement (Kitikedizah & Maimun Aqsha, 2022). This study, therefore, focuses on student achievement through the use of gamification during the TnL process.

RESEARCH HYPOTHESIS

The research hypothesis is as follows:

Null Hypothesis 1 (Hol)
There is no difference between the achievement of Form Two students at School A and B in the Federal Territory of Putrajaya involving the use of Circumference Board gamification in the topic of circles.

Alternative Hypothesis 1 (Hal)
There is a difference between the achievement of Form Two students at School A and School B in the Federal Territory of Putrajaya involving the use of Circumference Board gamification in the topic of circles.

Null Hypothesis 2 (Ho2)
There is no difference between the achievement of Form Two students between male and female students for Schools A and B in the Federal Territory of Putrajaya regarding the use of Circumference Board gamification in the topic of circles.

Alternative Hypothesis 2 (Ha2)
There is a difference between the achievement of Form Two students between male and female students for Schools A and B in the Federal Territory of Putrajaya regarding the use of Circumference Board gamification in the topic of circles.

LITERATURE REVIEW

Gamification-based Learning
Gamification-based learning uses game elements to increase student motivation and engagement in learning. A study by Foo and Ng (2022) showed that gamification through GeoGebra can improve students' problem-solving skills and interest, although limited to one school. Noor Amalina Nisa et al. (2022) found that gamification increases student motivation and performance through a fun learning environment. Kitikedizah and Maimun Aqsha (2022) also emphasized that gamification helps improve understanding, academic achievement, and makes teachers' tasks easier. Overall, gamification has proven effective in creating active, interactive, and meaningful learning.

Circumference Board Gamification
Circumference Board Gamification is rarely used to teach circumference in second-grade Mathematics. Circumference refers to the length of the line that surrounds a circle. However, students often make mistakes such as confusing the diameter and radius, as well as using the circumference formula incorrectly (Wicaksono & Martyanti, 2020). Studies show that visual and interactive approaches such as gamification can help overcome this confusion (Mohamad Basri et al., 2022). Gamification attracts students' interest, provides interactive learning experiences, and adapts teaching to students' needs (Hui & Mohd Affendi Ewan, 2022). Overall, it can improve students' understanding and achievement in the topic of circles.

Student Achievement

Student achievement in the context of education refers to the progress and learning outcomes a student has attained within a certain period. It can include improvements in knowledge, understanding, and mastery of the subject matter taught. Student achievement is often measured through tests, assessments, and observations conducted by teachers or educational researchers (Vidergor & Ben-Amram, 2020).

Circle

A circle is defined as a set of points that move at a constant distance from a fixed point (Ministry of Education Malaysia, 2017). This fixed point is known as the center of the circle, and the constant distance is called the radius (Subramaniam & Roslinda Rosli, 2024). The circle is the fifth topic in the Form Two Mathematics syllabus. It is also described as a closed curve referred to as the circumference or perimeter of the circle. The circle has several components, including the radius, diameter, chord, arc, sector, segment, and center.

Circumference of a Circle

The circumference of a circle refers to the line or path that surrounds the curve of the circle or any other circular part (Foo & Ng, 2022). It is an important concept in various fields, i.e., geometry, physics, and engineering. In the context of geometry, the circumference is the line that encircles the outer boundary of the circle, maintaining a constant distance from its center.

METHODOLOGY

Study Design

This study employs a quasi-experimental design in assessing the effectiveness of the Circumference Board gamification intervention on students' understanding of the topic of circles. Given the educational context, the quasi-experimental design is appropriate for examining the impact of an intervention when random assignment is not possible. The study compares student achievement before and after exposure to the gamification intervention using pre- and post-tests.

Internal Validity and Design Limitations

While a quasi-experimental design offers a practical approach, several potential threats to internal validity need to be addressed. These include confounding variables such as differences in teacher effectiveness, class dynamics, and students' prior exposure to gamification. To mitigate these issues, efforts were made to match the schools based on similar demographic and academic characteristics, ensuring that both schools are comparable in terms of educational environment. Additionally, teachers were trained to use the Circumference Board gamification in the same manner, reducing variability in the implementation of the intervention. However, it is acknowledged that these efforts cannot fully eliminate the possibility of teacher bias or differences in class dynamics.

Furthermore, prior exposure to gamification may influence how students engage with the intervention. To control for this, pre-test questions included items designed to gauge any previous experience with gamification, and this data was used as a covariate in the analysis to account for potential differences in prior exposure.

Sampling and Stratification

The study applied stratified random sampling to ensure representativeness of the target population, namely Form Two students from two schools in the Federal Territory of Putrajaya. Stratification was based on gender and academic ability, with separate strata for male and female students in both schools. This ensures that gender-based differences in achievement are systematically examined. However, the criteria for stratification, such as how academic ability was defined and measured, will be clarified in the methods section. Specifically, students were classified into high, medium, and low academic ability groups based on their previous assessment performances. The practical implementation of this stratification involved randomly selecting students from each stratum, ensuring a diverse sample that allows for generalization to the broader population of Form Two students in Putrajaya.

Statistical Analysis and Effect Sizes

The data analysis primarily employs paired t-tests to compare pre- and post-test scores, as well as independent t-tests to compare performance between the two schools and between male and female students. While statistical significance is important, the effect size will also be reported to assess the practical significance of the observed differences in student achievement. This will help to determine not just whether the intervention had an effect, but also the magnitude of that effect. Additionally, regression analysis will be employed to control for confounding variables such as prior exposure to gamification, ensuring that the observed effects are attributable to the intervention itself.

Reliability and Validity of Test Instruments

To ensure the validity and reliability of the test instruments used to measure achievement, the pre- and post-test questions were reviewed by educational experts for content validity and pilot-tested to assess reliability. The internal consistency of the tests was measured using Cronbach's alpha to ensure that the items were consistently assessing the intended constructs. The pre- and post-tests were designed to focus specifically on the topic of circles, with clear definitions of "achievement" and "performance" as the ability to demonstrate mastery of the topic, measured through a combination of conceptual understanding and problem-solving skills.

Critical Reflection on Limitations and Bias

While the quasi-experimental design is suitable for educational research, it is important to acknowledge its limitations critically. Despite efforts to control for confounding variables, the design cannot account for all potential biases, particularly those related to teacher differences or unobserved class dynamics. The lack of a control group (i.e., a group of students who did not receive the intervention) is a limitation; thus, causal inferences must be drawn cautiously. Additionally, while the stratified sampling method increases representativeness, the findings may not fully generalize to other regions or age groups beyond the study's specific context.

Gender and Achievement

In examining gender differences in achievement, the study hypothesizes that the gamification intervention may have differential effects based on gender, with potential implications for how male and female students engage with the learning material. However, the discussion of gender and learning should be expanded beyond general theoretical assertions. Future research could explore underlying factors such as gendered learning styles or social influences that may contribute to any observed differences in performance. Empirical studies on gender and gamification would provide a more solid foundation for interpreting the results in the context of this study.

FINDINGS

Data Analysis

Data analysis involves comparing results across groups and making decisions about the achievement of the study's goals (Dibekulu, 2020). In the data analysis of this study, a quantitative approach was used using the Statistical Package for the Social Sciences (SPSS) Version 26 software. The t-test is an inferential statistical test that compares two sets of data (Abraham & Supriyati, 2022). This allows for analysis of differences between two groups, which can show significant increases or differences after the learning process is implemented. Paired t-tests are used to compare mean differences in groups before and after the learning process (Isnawan, 2020). Researchers can test the study hypothesis and draw conclusions through t-tests. Through this test, researchers can see differences in student achievement using the Circumference Board in the circle topic. When the significance value of the t-test is less than or equal to 0.05, then H null is rejected. However, when the significance value of the t-test is greater than 0.05, it can be concluded that the use of Circumference Board gamification is effective and the null H is rejected (Isnawan, 2020).

However, if the data obtained is not normal, another alternative should be used, namely the Mann-Whitney U Test. The Mann-Whitney U Test is a non-parametric test used to compare two independent samples when the assumption of normal distribution is not met. This method is an alternative used to

test hypotheses when the t-test is not appropriate to use (Meléndez et al., 2020). Mann-Whitney U is a test used to compare the medians of two groups. This is different from the t-test, which compares the mean. Mann-Whitney U uses the median as a measurement, different from the t-test.

To compare the achievement of secondary school students in circle geometry using the Circumference Board gamification between School A and B in the Federal Territory of Putrajaya, the t-test or Mann-Whitney U test, depending on the data. For the t-test, the null hypothesis states that there is no significant difference in achievement between schools, while the alternative suggests otherwise. Similarly, the null hypothesis of the Mann-Whitney U test indicates that there is no significant difference in medians, with the alternative stating the opposite. After formulating the hypothesis, data analysis uses appropriate tests, the t-test for normal distribution, and the Mann-Whitney U test for non-parametric or ordinal data, to draw valid conclusions.

The results of this analysis allow the researcher to confirm or reject the study hypothesis, as well as provide insight into the effectiveness of the gamification carried out. The study report includes these findings and their impact in the context of mathematics teaching and learning in schools. SPSS data analysis is crucial in supporting the study's conclusions with strong and valid evidence. The application of gamification in mathematics education, especially in teaching the topic of the circumference of a circle, opens up opportunities for a comprehensive approach in improving student achievement. Table 1 is the marks for Form Two students of School A, and Table 2 is the marks for Form Two students of School B through the Circumference Board gamification.

Table 1.
Marks for Male Form Two students at School A

Student	Pre Test	Post Test
Student 1	66	90
Student 2	40	70
Student 3	85	90
Student 4	100	100
Student 5	10	70
Student 6	7	60
Student 7	54	70
Student 8	40	80
Student 9	14	60
Student 10	20	70
Student 11	60	90
Student 12	33	60
Student 13	46	70
Student 14	66	90
Student 15	40	80

Table 2.
Marks for Female Form Two students at School A

Student	Pre Test	Post Test
Student 1	40	80
Student 2	60	65
Student 3	20	55
Student 4	20	65
Student 5	93	100
Student 6	93	100
Student 7	80	85
Student 8	100	100
Student 9	33	70
Student 10	27	60
Student 11	47	65

Student 12	100	100
Student 13	20	65
Student 14	53	75
Student 15	46	80

Table 3.
Marks for Male Form Two students at School B

Student	Pre Test	Post Test
Student 1	40	75
Student 2	46	80
Student 3	26	70
Student 4	33	75
Student 5	33	80
Student 6	46	95
Student 7	60	100
Student 8	66	90
Student 9	80	100
Student 10	66	85
Student 11	60	90
Student 12	60	100
Student 13	54	80
Student 14	40	80
Student 15	40	70

Table 4.
Marks for Female Form Two students at School B

Student	Pre Test	Post Test
Student 1	60	85
Student 2	100	100
Student 3	94	100
Student 4	20	80
Student 5	100	100
Student 6	60	90
Student 7	46	85
Student 8	100	100
Student 9	80	90
Student 10	100	85
Student 11	46	70
Student 12	20	80
Student 13	40	100
Student 14	40	75
Student 15	20	85

The results of data collection showed a significant increase in the achievement of post-test scores, with several students obtaining full marks. This increase reflects the positive impact of learning through the gamification of the Circumference Board, where no student experienced a decrease in scores after the learning session.

Comparison of the Achievement Levels of Form Two Students of School A and B

This gamification approach was introduced as an innovative strategy to increase students' interest and understanding in Mathematics, especially in understanding the concept of the circumference of a circle. This comparison is expected to provide a clear picture of the effectiveness of gamification in improving student achievement in the two schools involved. Table 3 is a statistical table for Form Two Student achievements for Schools A and B.

Table 5.
Statistical Table for Form Two Student Achievements for School A and B

School	Number	Mean		Standard Deviation	
		PRE	POST	PRE	POST
School A					
	30	50.43	77.17	28.73	14.30
School B	30	55.87	86.5	25.02	10.27

Table 3 shows the improvement in the achievement of Form Two students from Schools A and B after learning using Circumference Board gamification. School B students recorded higher mean scores in the pre-test of 55.87 and post-test of 86.5 compared to School A, which obtained mean pre-test scores of 50.43 and post-test of 77.17. The lower standard deviation in the post-test for both schools indicates more consistent achievement, with School B recording the smallest standard deviation of 10.27. This indicates that gamification through Circumference Board is effective in improving student performance, with School B students showing more uniform and higher achievement overall.

Table 6.
Paired T-Test Results for Form Two Student Achievement for School A and B

School	Mean	T value	dof	p
School A	-26.73	-8.421	29	<0.001
School B	-30.63	-8.468	29	<0.001

Table 4 shows that there is a significant difference in the results of statistical analysis in student achievement before and after the use of Circumference Board gamification for both schools. For School A, the difference in mean achievement was -26.73 with a t value = -8.421 and $p < 0.001$, indicating a significant improvement in performance after learning. For School B, the difference in mean achievement was higher, namely -30.63, with a t value = -8.468 and $p < 0.001$, also indicating significant improvement in performance. The p value < 0.001 for both schools confirms that this improvement is highly statistically significant. Although both schools recorded significant improvements, School B showed a larger mean difference, reflecting the higher impact of gamification on student achievements.

The results of the analysis show that there is a significant difference in the achievement of form two students at School A and School B when using the Circumference Board gamification in learning the topic of circles. This finding rejects the null hypothesis (H01), which states that there is no difference in achievement between the achievement of form two students at School A and B in Putrajaya, which involves the use of the Circumference Board gamification in the topic of circles.

Additional analysis also shows a significant increase in scores for students who use the Circumference Board as a learning tool, further strengthening the results of this study. Comparison with previous studies reinforces the findings, where gamification is proven to have a positive impact on students' academic achievement in the subject of Mathematics. This proves that gamification tools such as the Circumference Board not only attract students' interest but are also effective in improving conceptual understanding.

This finding is in line with literature studies, which also show the effectiveness of gamification in improving students' academic achievement. For example, a study by Foo and Ng (2022) showed that learning using GeoGebra gamification can improve problem-solving skills and stimulate students' interest. This is in line with the findings of this study, where the use of the Circumference Board increases students' achievement in the topic of circles. In addition, Noor Amalina Nisa et al. (2022) found that gamification increases students' motivation and learning performance, which supports the findings of this study.

A study by Wicaksono and Martyanti (2020) showed that visual and interactive approaches, such as gamification, can help students understand the concept of circle circumference better. This aligns with the findings of this study, where the use of the Circumference Board helps students understand and calculate the circumference of a circle more accurately. A study by Rewathy and Siti Mistima (2022) showed that male students' achievements in mathematics and circles are weaker than those of females, possibly due to less appropriate teaching approaches. This may contribute to the difference in achievement between male and female students in the topic of circles, as shown in this study.

Overall, these findings emphasize the importance of further exploring the use of gamification methods in mathematics education. This innovative approach has the potential to significantly improve student achievement, especially in the topic of circles. Further research is needed to expand understanding of the effectiveness of gamification in different learning contexts, thus contributing to the development of 21st-century pedagogy (Nor Atirah & Siti Mistima, 2022).

Comparison of Achievements of Male and Female Form Two Students of School A and B

This study aims to compare the achievements of male and female Form Two students from Schools A and B on the use of Circumference Board gamification in learning the topic of circles. This gamification approach was introduced to increase students' understanding and interest in the concept of the circumference of a circle, while assessing the effectiveness of this method based on gender differences in achievement. This comparison is expected to provide in-depth insights into the effectiveness of gamification in supporting inclusive and effective learning for male and female students. Table 5 is a statistical table of male and female Form Two students of Schools A and B.

Table 7.

Statistical Table of Student Achievement Data for Form Two between Male and Female Students of School A and B

	Gender	n	Mean	Standard Deviation
PRE	Male	30	47.70	21.70
	Female	30	58.60	30.57
POST	Male	30	80.67	12.30
	Female	30	83.00	14.18

Table 4.5 presents descriptive statistics comparing the post-test scores between male and female students. The mean pre-test score for male students was 47.70 with a standard deviation of 21.70, while female students recorded a mean score of 58.60 with a standard deviation of 30.57. For the post-test, the mean score for male students increased to 80.67 with a standard deviation of 12.30, while the mean score for female students was 83.00 with a standard deviation of 14.18.

Table 8.

Independent T-Test Results for Form Two Student Achievement between Male and Female Students Involving the use of a Circumference Board

	Jantina	n	mean	t value	Dof	p value
PRE	Male	30	47.7	1.592	29	0.583
	Female	30	58.6		29	
POST	Male	30	80.67	-0.6809	29	0.25
	Female	39	83		29	

Note. n=30

Table 6 shows the independent t-test results for Form Two Student achievement between male and female Students involving the use of a Circumference Board. For the pre-test, the mean score of male students was 47.7 with a t value = 1.592 and p = 0.583, which indicates that there is no significant difference between the pre-test scores of male and female students, because the p value is greater than 0.05. For the post-test, the mean score of male students was 80.67, while the mean score of female students was 83.0, with a t value = -0.6809 and p = 0.25, also indicating that there is no

significant difference between the two groups after using the Circumference Board gamification. These results confirm that the use of gamification has a similar effect on both genders in improving their performance.

CONCLUSION

The results of the analysis show that there is no significant difference in the achievement of male and female Form Two students at Schools A and B when using Circumference Board gamification in the circle topic. This finding supports the null hypothesis (Ho2) that there is no difference in achievement based on gender, indicating that Circumference Board gamification is effective in consistently improving student academic performance regardless of gender. This finding also proves that the gamification approach can provide equal opportunities for male and female students to succeed in learning.

These results underline that academic performance is not determined by gender factors, but rather by the effectiveness of innovative and appropriate teaching approaches. In other words, gamification can be an inclusive medium to eliminate the perception and achievement gap among students (Hui & Mohd Affendi Ewan, 2022).

This study shows that the use of the Circumference Board gamification in circle learning is effective in improving student achievement regardless of gender. This finding thus rejects the view that female students are smarter or male students are smarter in certain fields. On the contrary, it highlights the importance of innovative and inclusive teaching approaches such as gamification, which provide equal opportunities for all students to succeed. This finding helps foster the understanding that intelligence is not limited to gender but depends on the approach and learning effort.

Overall, this study proves a significant difference in student achievement between School A and School B when the concept of a circle is taught using the gamification of the Circumference Board. The first objective of the study was achieved, where students at School B showed better performance than those at School A. In addition, in line with the second objective, this study also found that the use of the Circumference Board had a balanced impact on both genders, indicating that this teaching aid is suitable for use regardless of gender differences.

From a learning theory perspective, this study supports the Connectivism Theory, which emphasizes the importance of interconnected relationships in learning. Circumference Board, as a form of gamification, helps students connect mathematical concepts with interactive experiences, making learning more interesting and effective. Through the use of technology and game elements, students can build a deeper understanding of the concept of a circle by increasing their focus and interest in learning.

In addition, this study also aligns with the principles of the Constructivism Theory, which states that students actively construct knowledge through experience and reflection. The use of the Circumference Board provides students with the opportunity to explore and understand the concept of a circle more meaningfully through interaction and practical activities. This approach encourages more active and deeper learning, where students not only receive information but also build their own understanding through direct experience.

Overall, the use of gamification in mathematics learning, especially through the Circumference Board, has proven its effectiveness in improving student achievement. It not only helps in understanding the concept of a circle but also supports more interactive and meaningful learning. Therefore, integrating gamification in teaching and learning should be considered an effective strategy in improving the quality of mathematics education in schools.

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