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DUALCOLOR AND PINTEGER GAMIFICATION: A COMPARISON OF FORM ONE STUDENTS' ACHIEVEMENT IN INTEGER ARITHMETIC

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ABSTRACT

Recent developments in educational technology have changed how teachers deliver mathematics education through gamification-based approaches (GBA). These methods aim to boost student interest and participation. This study evaluates two gamification methods, DualColor and PInteger, focusing on arithmetic operations with integers. The sample for this study included Form One students from a secondary school in Rawang, chosen using simple random sampling. A pre-experimental One-Shot Case Study design was used, implemented sequentially with a single group exposed to two distinct gamification approaches. The research tools consisted of two sets of post-test questions at different difficulty levels. Data were analysed using descriptive statistics and inferential statistics with the paired-samples t-test through SPSS software. The inferential results showed no significant difference in overall mathematics achievement and across difficulty levels between the DualColor and PInteger gamification methods ($p > 0.05$). However, the descriptive results indicated that DualColor had higher mean scores at the moderate level (8.13) and the Higher Order Thinking Skills (HOTS) level (2.27) compared to PInteger. Overall, this study compares students' mathematics achievement between the two gamification methods and evaluates achievement based on question difficulty levels: easy, moderate, and higher-order thinking skills (HOTS).

Keywords: *DualColor gamification, PInteger gamification, difficulty level, integer arithmetic operations, mathematics achievement.*

INTRODUCTION

Mathematics is one of the most important subjects in school years because it teaches reasoning, logical thinking, and problem-solving ability. At the lower secondary level, new mathematical concepts are introduced, and it lays a foundation for advanced learning. Among the core topics studied are the addition, subtraction, and application of positive and negative integers. Students need to master integer operations, as it lays the foundation for understanding required for many other mathematical topics and helps them solve problems in other subjects too.

Integer arithmetic is important, but many students still find it difficult to learn. The struggle that students face is in recognizing negative and positive signs and when to use the additive or multiplicative property while performing calculations. According to Borhman and Abdul Karim (2023), using visual and manipulative teaching aids in lessons could help students understand the relationship between positive and negative numbers. Their results indicated that students improved their understanding of integer operations when the learning activities included interactive experiences and substantive content.

Newer trends in education have helped teachers adopt more interesting and student-centred pedagogy. One approach with increasing attention is gamification. Gamification involves integrating game elements (such as challenges, rewards, levels, and competition) into learning activities to enhance student motivation and engagement (Purba et al., 2024). Gamification motivates students to actively engage in learning and have a more interactive classroom experience. Similarly, Maryana et al. (2024) found that gamification increases students' motivation and promotes more efficient learning through engaging students in game-based activities. This finding is supported by Jutin and Maat (2024), who reported that gamification improves conceptual understanding and lowers mathematics anxiety among secondary school students.

The implementation of gamification is closely related to the principles of student-centred learning, which emphasise active involvement and meaningful learning experiences. In Malaysia, such approaches are in line with the aspirations of the Malaysian Education Development Plan (PPPM) 2013–2025 (Ministry of Education Malaysia, 2013), which promotes 21st-century learning and encourages the integration of innovative teaching strategies in the classroom. Furthermore, the use of gamification is in line with the Constructivist Learning Theory, which sees learning as an active process where students build knowledge through experience and interaction. Lathifah et al. (2024) explained that learning becomes more meaningful when students are given opportunities to explore, interact, and connect new knowledge with the knowledge they already have.

Recent national and international assessment reports show the need to increase students' understanding of mathematical concepts. The Trends in International Mathematics and Science Study (TIMSS) 2023 reported a decline in Malaysia's mathematics performance, with the average score decreasing from 461 in 2019 to 411 in 2023 (Ministry of Education Malaysia, 2024). The report also noted weaknesses in the Number domain, which covers foundational topics such as integers, fractions, decimals, and ratios. These findings suggest that students continue to face challenges in mastering basic numerical concepts, indicating the need for more effective instructional approaches that emphasise conceptual understanding rather than procedural memorisation.

Integer concepts form the foundation for learning advanced mathematical topics such as algebra, equations, and coordinate geometry. A strong understanding of positive and negative numbers is essential for developing mathematical reasoning and problem-solving skills. Students who lack conceptual understanding of integers often encounter difficulties when solving problems involving multiple operations and abstract thinking. According to Kurniasi et al. (2024), proficiency in integer arithmetic contributes to the development of mathematical skills and critical thinking abilities. Therefore, strengthening students' understanding of integer concepts remains an important priority in mathematics education, as it supports learning across a wide range of mathematical topics and promotes deeper conceptual understanding.

This paper introduces two gamification methods, DualColor and PInteger, to facilitate students' learning of integer arithmetic. Both methods integrate visual and manipulative elements designed to help students understand addition, subtraction, multiplication, and division involving integers. Several reports also found that the use of visual and manipulative elements enhanced students' conceptual learning and engagement in the active math learning process (Low et al., 2024). With the use of colours, symbols, and interactive activities, students are expected to have a better understanding of positive and negative numbers and be actively engaged in the learning process. The effectiveness of these gamification tools in supporting students' achievement will be further explored in this study.

The integration of visual and manipulative learning materials can be an effective approach for facilitating students' understanding of abstract mathematical concepts. Through direct interaction with learning materials, students can develop meaningful connections between mathematical ideas rather than relying solely on procedural memorisation. Such learning experiences not only encourage active participation but also promote deeper conceptual understanding. Low et al. (2024) reported that the use of visual and manipulative activities enhances students' conceptual understanding and engagement in the

learning process. Similarly, Ahmad and Siller (2024) highlighted that concrete learning materials support students in visualising mathematical concepts more effectively.

Despite the growing interest in gamification, students continue to experience difficulties in mastering arithmetic operations involving integers. According to Kurniasi et al. (2024), integer operations are an important part of learning mathematics in lower secondary school because they are the basis for higher-level thinking and problem-solving skills. However, many students still struggle to understand the conceptual meaning of positive and negative numbers and often memorise procedures rather than understanding the fundamental concepts. According to Harun et al. (2023), one source of students' misunderstanding about operating with integers, which resulted in conceptual and procedural errors, is the misconception of negative numbers as the subtraction sign.

Similar findings were reported by Molina and Ibañez (2024), where Form One students often experienced challenges when carrying out addition, subtraction, multiplication, and division of integers. These problems are more visible when students have to solve mixed operations or contextual problems. Therefore, students may develop a negative perception of the topic and become less engaged in mathematics lessons.

Studies have shown that manipulative and game-based instructional tools can be more effective in helping students understand mathematical concepts than traditional teaching methods. Ahmad and Siller (2024) found that manipulative learning materials, either physical or digital, aid students in visualising mathematical ideas and enhance conceptual understanding. Similarly, Jamaludin et al. (2023) reported the effectiveness of the Dolphin Jump Number Line in helping students understand multiplication of integers through interactive learning experiences. The results demonstrate that visual and manipulative approaches to learning can be very beneficial for students to learn integers. Anton and Abrahamson (2025) also stated that movement-based and number-line simulation activities support students in visualising integer-related content to minimize conceptual errors.

Furthermore, students' achievement in integer arithmetic may differ depending on the level of difficulty of the questions. Wibowo et al. (2022) found that students with procedural memorisation alone often found more difficulty in answering more complex questions that require deeper conceptual understanding and higher-order thinking skills. With the rising of difficulty, students may have difficulty in choosing suitable solution strategies and correctly applying integer rules. Moreover, Philpot et al. (2023) mentioned that in mathematics assessment, the test should reflect a student's capacity to recall and demonstrate reasoning and higher-order processes across various levels of cognition.

Although there are a number of teaching aids and gamification tools to support the learning of integers, most of the previous studies have focused on assessing a single intervention without comparing its effectiveness with other gamification approaches. For example, Jamaludin et al. (2023) examined the effectiveness of the Dolphin Jump Number Line, while Borhman and Abdul Karim (2023) developed a colour-based teaching kit to improve students' understanding of integer operations. In addition, few studies have compared gamification approaches that combine colour-based visual representations and physical manipulative activities within the same instructional context, particularly for arithmetic operations involving integers.

Previous studies have primarily focused on examining the effectiveness of individual gamification approaches or learning materials, with limited attention given to comparing different gamification methods within the same group of students. As a result, mathematics teachers have limited empirical evidence to determine which type of gamification is more effective in supporting students' performance across different levels of question difficulty. Therefore, this study compares two teacher-developed gamification approaches, namely DualColor and PInteger, within the same learning context. The findings are expected to provide valuable insights into selecting appropriate instructional approaches for teaching integer arithmetic (Jamaludin et al., 2023).

Therefore, the present study was conducted to compare the achievement of students in learning integer arithmetic in DualColor gamification and PInteger gamification. Furthermore, the study examines students' achievement according to the levels of difficulty of questions, i.e., easy, moderate, and Higher Order Thinking Skills (HOTS). The findings are expected to provide useful information for mathematics teachers in choosing appropriate gamification techniques to facilitate students' comprehension of integer concepts and to improve mathematics achievement.

Specifically, this study aimed to:

(i) compare Form One students' achievement in integer arithmetic between DualColor and PInteger gamification approaches; and

(ii) compare students' achievement based on the question difficulty level (easy, moderate, and Higher Order Thinking Skills) between both approaches of gamification.

METHODOLOGY

Research Design

This study was conducted using a quantitative approach in the form of a pre-experimental One-Shot Case Study design, adapted to evaluate a single group exposed sequentially to two gamification approaches. The design involves a single group of Form One students who are exposed to two gamification approaches, namely DualColor and PInteger gamification in learning arithmetic operations involving integers. Students' achievement was measured by two post-tests given after the implementation of each gamification strategy.

The pre-experimental design was considered appropriate as it allowed for the comparison of students' achievement when they experienced the two gamification approaches in the same learning context. The same group of students took part in both learning sessions, which allowed us to minimise individual differences between participants and directly compare achievement between DualColor and PInteger gamification. The study was related to the comparison of the overall achievement of the students, as well as their achievement according to the difficulty levels of questions, namely easy, moderate, and Higher Order Thinking Skills (HOTS).

Using the same group of students in both learning sessions ensured consistency in learning objectives, classroom conditions, and assessment methods. This design reduced the potential influence of individual differences and allowed for a more meaningful comparison between the DualColor and PInteger gamification approaches. As a result, variations in students' performance could be examined more reliably within a consistent learning environment.

Participants

This study was conducted in a secondary school in Rawang, Selangor. This school was chosen because the students had already learned arithmetic operations with integers, and most of them shared a similar academic background. That made it easier to fairly test the two gamification methods. In addition, students' attendance was consistent throughout the study, enabling the implementation of both gamification sessions without significant interruption.

There were 45 Form One students at the school who had already completed the integer arithmetic topic. From this population, 15 students were selected using simple random sampling, which means every student had the same chance of being chosen, minimizing potential bias. (Ramadani et al., 2025). These students participated in both the DualColor and PInteger gamification activities and completed the post-tests after each session. As only one group was involved, a pre-experimental One-Shot Case Study design was used, where post-tests were conducted sequentially to compare student performance across both gamification sessions for the same group of students.

The selected participants shared a similar background, as they had all completed the same topic, since all of them had already learned about the topic before being part of the study. This made sure that the students had enough background knowledge to understand the two gamifications and also take the

achievement tests. Simple random sampling also gave each of the student's equal chances to be part of the sample, making it fair (Ramadani et al., 2025).

Instruments

Three research instruments were employed in this study: DualColor gamification, PInteger gamification, and two achievement tests. DualColor and PInteger were designed by the researcher in order to help students learn arithmetic operations that involve integers. Both gamifications were developed using visual and manipulative learning in order to enable students to understand addition, subtraction, multiplication, and division of positive and negative integers. The two gamification techniques have been designed by the researcher specifically for this research project and involve simple classroom materials which can be easily made and used within the educational environment. DualColor is colour-based visual representation, while PInteger focuses on hands-on manipulation through physical objects. Even though different approaches to learning have been used, both of them are intended to increase students' conceptual knowledge and engagement.

In DualColor, there is an application of colour as a representation of positive and negative integers. Through the use of this technique, it enables the students to see the process involved in the integer operation more visually. In PInteger gamification, there are manipulative pins that represent positive and negative integers. This gamification allows the students to learn about integers through the use of manipulatives. Figure 1 shows the DualColor gamification, while Figure 2 shows the PInteger gamification.

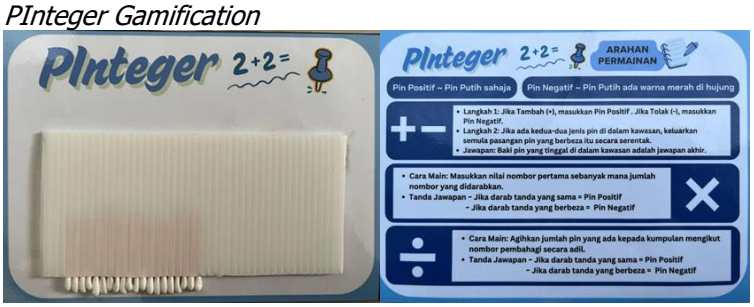
Figure 1

DualColor Gamification



Figure 2

PInteger Gamification



The performance of the students was evaluated using two post-test assessments with similar levels of difficulty based on the Form One Mathematics curriculum. Each post-test assessment consisted of ten questions involving integer computations. These questions were grouped into three categories according to their level of difficulty, namely: easy (Questions 1–3), medium (Questions 4–7), and Higher Order Thinking Skills (Questions 8–10). The post-test questions were adapted from the Form One Mathematics Textbook and other supplementary mathematics books.

Instrument Validation

To ensure the research tools were suitable and clear, both the achievement tests and marking schemes went through a content validation process. Three experts reviewed the instruments: one secondary school mathematics teacher and two mathematics education lecturers. The validation focused on the relevance of the test items, the clarity of instructions, the appropriateness of difficulty levels (Zulkefly & Yusof, 2025), and how well they matched the learning goals for arithmetic operations with integers.

Based on the experts' feedback, several changes were made to the wording, presentation, and structure of the test items before using the instruments in the actual study. A pilot study was also conducted to test the suitability of the instruments and to identify any potential issues during implementation. The feedback from this pilot study helped further improve the instruments, making sure they were suitable for Form One students and effective at measuring students' achievement in integer arithmetic. This experiment also provided an opportunity to observe how clear the instructions were and whether the time assigned was appropriate for the students to understand the test format. Minor adjustments were made where necessary to ensure that the measuring tools were able to assess the achievements of the students in performing the arithmetic operations using integers.

Data Collection Procedure

Before the data collection process, approval was obtained from the school administration and the mathematics teacher involved in the study. The research instruments, including the gamification tools and achievement tests, were reviewed and refined based on expert feedback and pilot study findings before being implemented in the actual study.

The study involved a single group of students who participated in two consecutive learning sessions. Students first learned arithmetic operations involving integers using the DualColor gamification approach and subsequently completed the first achievement test. The same students then participated in a second learning session using the PInteger gamification approach, followed by the second achievement test. All completed answer scripts were checked for completeness before the scores were recorded and analysed using the Statistical Package for the Social Sciences (SPSS) software.

Data Analysis

The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS) software. Descriptive statistics, such as mean, standard deviation, minimum score, and maximum score, summarized students' achievement for both DualColor and PInteger gamification approaches. Before the inferential analysis, the Shapiro-Wilk test examined the normality of the data distribution since the sample size was fewer than 50 participants. Because the data met the normality assumption, a paired-samples t-test was used to compare students' achievement between the two gamification approaches and across different question difficulty levels: easy, moderate, and Higher Order Thinking Skills. Statistical significance was determined at $p < 0.05$. Furthermore, students' performance was also assessed based on the difficulty level of questions to determine the trends in their performance for easy, medium, and HOTS questions. This enabled another evaluation of the concepts and problem-solving skills of students after using the two gamification techniques.

Research Hypotheses

Based on the research objectives, the following null hypotheses were tested:

1. H01: There is no significant difference in Form One students' achievement between DualColor and PInteger gamification in integer arithmetic.
2. H02: There is no significant difference in Form One students' achievement according to question difficulty levels (easy, moderate, and Higher Order Thinking Skills) between DualColor and PInteger gamification.

FINDINGS

Overall Students' Achievement

To compare the overall achievement of Form One students after using the DualColor and PInteger gamification approaches, descriptive statistics were analysed based on the mean score, standard deviation, minimum score, and maximum score. The descriptive statistics of students' overall achievement are presented in Table 1.

Table 1

Descriptive Statistics of Students' Achievement

Gamification	N	Minimum	Maximum	Mean	Standard Deviation
DualColor	15	4	25	15.73	5.788
PInteger	15	7	25	12.87	5.514

Results from the analysis presented in Table 1 reveal that the students who participated in the DualColor gamification had a mean score (M = 15.73, SD = 5.788) higher than those who participated in the PInteger gamification (M = 12.87, SD = 5.514). Both gamification approaches recorded the same maximum score of 25, while the minimum scores were 4 for DualColor and 7 for PInteger. Overall, the descriptive results indicate that the DualColor gamification approach achieved a slightly higher mean score than the PInteger gamification approach.

Before conducting the inferential analysis, the normality of the data distribution was examined using the Shapiro–Wilk test. The results of the normality test are presented in Table 2.

Table 2

Shapiro–Wilk Test of Overall Students' Achievement

Variable	Statistic	df	Sig.
DualColor	0.954	15	0.585
PInteger	0.898	15	0.088

Based on the information from the normality testing provided in Table 2, as the p-values for both the DualColor approach (p = 0.585) and the PInteger approach (p = 0.088) were higher than 0.05, the data set for both gamification methods was normally distributed, and thus a paired-samples t-test was used to compare the students' achievement. Therefore, a paired-samples t-test was applied to establish the effects of the two gamification methods, DualColor and PInteger, on the students' overall achievement. The results of the paired-samples t-test are presented in Table 3.

Table 3

Paired-Samples t-test for Overall Students' Achievement

Comparison	Mean Difference	Standard Deviation	Standard Error Mean	t	df	Sig. (2-tailed)
DualColor – PInteger	2.867	6.707	1.732	1.655	14	0.120

From Table 3, the value of the paired-samples t-test was .120, which was greater than the level of significance of .05 (p> 0.05). This result indicates that there was no significant difference in the total achievements of Form One students between the DualColor and PInteger gamification strategies. Thus, the null hypothesis (H01) could not be rejected, and there was no significant difference between the DualColor and PInteger gamification strategies concerning students' achievement in arithmetic operations involving integers.

Students' Achievement by Question Difficulty Level

This section compares student performance across three difficulty levels: easy, moderate, and Higher Order Thinking Skills (HOTS), under the DualColor and PInteger gamification methods. Descriptive statistics were used to analyze the general performance trends within each difficulty category. Following this, inferential statistics were applied to determine if there is any significant difference in student performance between the two gamification methods. The descriptive statistics for students' achievement according to question difficulty level are presented in Table 4.

Table 4

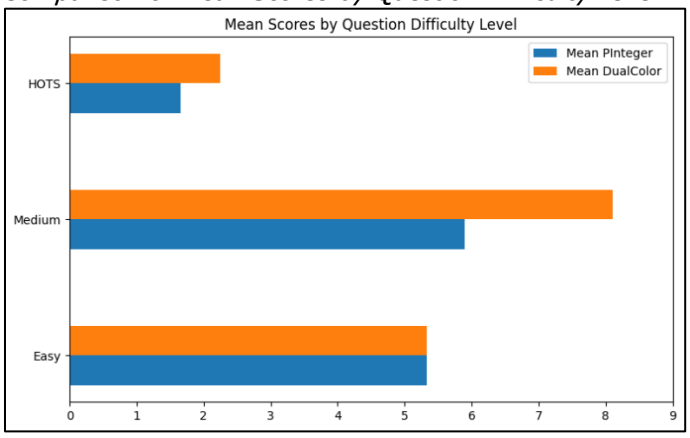
Descriptive Statistics of Students' Achievement by Question Difficulty Level

Difficulty Level	Gamification	Minimum	Maximum	Mean	SD
Easy	DualColor	2	6	5.33	1.234
	PInteger	2	6	5.33	1.234
Moderate	DualColor	0	12	8.13	3.357
	PInteger	1	12	5.87	3.642
HOTS	DualColor	0	10	2.27	3.369
	PInteger	0	8	1.67	2.664

As shown in Table 4, both gamification techniques resulted in the same mean score at the easy level (M = 5.33). However, at the moderate level, DualColor achieved a higher mean score (M = 8.13) compared to PInteger (M = 5.87). A similar trend was observed at the HOTS level, where the mean score for DualColor (M = 2.27) was slightly higher than PInteger (M = 1.67). Based on these descriptive results, the DualColor method led to higher student achievement at both the moderate and HOTS levels. Figure 3 shows the mean scores for all three difficulty levels across both gamification methods. This chart provides a clear visual comparison of student performance at different levels of difficulty.

Figure 3

Comparison of Mean Scores by Question Difficulty Level



Based on the analysis of Figure 3 above, it is shown that there are no significant differences between the two gamification techniques in achievement at the easy level, while DualColor has obtained a relatively better mean score in the moderate and HOTS levels. A paired-samples t-test was performed on each level of difficulty of the question to see whether the difference found was statistically significant, and the results are presented in Table 5.

Table 5

Paired-Samples t-test Results of Students' Achievement by Question Difficulty Level

Difficulty Level	Mean Difference	t	df	Sig.
Easy	0.000	0.000	14	1.000
Moderate	2.267	1.839	14	0.087
HOTS	0.600	0.854	14	0.407

As presented in Table 5, no significant differences were found between the DualColor and PInteger gamification approaches at the easy (p = 1.000), moderate (p = .087), and HOTS (p = .407) levels, as all significance values were greater than .05. Therefore, the null hypothesis (H02) failed to be rejected, indicating that both gamification approaches produced comparable achievement across all question difficulty levels.

DISCUSSION

The findings of this study indicate that there was no significant difference in students' achievement between the DualColor and PInteger gamification approaches. The paired-samples t-test revealed no statistically significant difference between the mean scores obtained through DualColor and PInteger, although DualColor recorded a slightly higher mean score. Similar findings were observed across the three levels of question difficulty, namely easy, moderate, and Higher Order Thinking Skills (HOTS), suggesting that no statistically significant difference was detected between the two gamification approaches in enhancing students' understanding of integer arithmetic.

The findings of this study are consistent with previous research highlighting the benefits of gamification in mathematics learning. Purba et al. (2024) reported that gamification enhances students' engagement and motivation through interactive learning activities. Similarly, Srimuliyani (2023) found that game elements such as challenges and immediate feedback contribute to meaningful learning experiences. Although DualColor and PInteger gamification employ different learning mechanisms, both incorporate interactive and visual elements, and no statistically significant difference was detected.

The similar achievement observed between the two gamification approaches may also be attributed to the use of visual and manipulative learning materials. Previous studies have demonstrated that concrete and visual representations can enhance students' conceptual understanding of abstract mathematical concepts (Ahmad & Siller, 2024). In the present study, DualColor employed colour-coding techniques, while PInteger involved the physical manipulation of pins. Although these differences existed, both approaches facilitated conceptual learning by enabling students to visualise positive and negative integers more effectively.

Further, the results indicate that the success of gamification is not related to the type of instructional materials used but rather to the opportunities provided for students to actively participate in the learning process. Both gamification (DualColor and PInteger) encouraged students to actively engage in learning through visualization and hands-on activities involving integer operations. This engagement may explain why students achieved similar levels of performance when using both games, despite the different learning mechanisms employed by each approach.

There were no significant differences among the three levels of question difficulty, but in general, students showed higher scores for easy and moderate questions than HOTS questions. This finding is consistent with Philpot et al. (2023), who reported that more advanced mathematical tasks require a deeper conceptual understanding and stronger problem-solving skills. Students may still use procedural knowledge to solve complex integer problems, making HOTS questions more difficult. DualColor and PInteger gamification both had visual and manipulative components that assisted students in learning. However, developing higher-order thinking skills in integer arithmetic may require additional practice and sustained exposure to challenging mathematical tasks. This may be attributed to the short duration of the intervention, and the students were not familiar with the gamification methods employed. Considering that both the interventions took place over a short duration of time, there could be a high probability that the students had insufficient time to adapt to the methods of learning employed or even use the gamification methods effectively.

The findings are also consistent with Constructivist Learning Theory, which emphasises that students actively construct knowledge through interaction, exploration and learning experiences rather than passively receiving information. DualColor and PInteger gamification gave students opportunities to manipulate learning materials, visualize integer concepts, and actively engage in problem-solving

activities. These learning experiences encouraged students to connect new knowledge with their existing understanding and develop conceptual meaning through hands-on activities. According to Lathifah et al. (2024), such learning environments promote meaningful learning and strengthen students' conceptual understanding. This may explain why no statistically significant difference in student achievement was observed between the two gamification approaches in learning arithmetic operations involving integers.

Several limitations of this study should be considered when interpreting the findings. First, the small sample size from a single secondary school limits the results' generalisability. Second, because all students experienced DualColor before PInteger, sequence effects such as fatigue or carryover effects may have occurred. However, to reduce direct practice and memorization effects, two different sets of post-test items with equivalent difficulty levels were used after each session. Future studies could adopt a counterbalanced design to avoid potential sequence effects.

From a practical perspective, the findings suggest that mathematics teachers may choose either DualColor or PInteger based on classroom needs, learning objectives, and the availability of resources. As neither gamification approach demonstrated a statistically significant advantage over the other, teachers can integrate visual or manipulative game-based activities into mathematics lessons without compromising students' learning outcomes. Furthermore, these approaches could promote active engagement, enhance learning motivation, and reduce students' anxiety when learning integer arithmetic. Therefore, the integration of gamification into classroom instruction can provide a more interactive and meaningful learning experience while strengthening students' conceptual understanding of arithmetic operations involving integers. These results also indicate the practicality of using gamification materials made by teachers without the need for any advanced technology or expensive resources. This is a practical solution for mathematics teachers who want to make their classes more fun and student-oriented but without the need for any complicated materials.

CONCLUSION

This particular study involved the comparison of Form One students' achievements in performing mathematical operations on integers using two gamification methods: DualColor and PInteger. From the results obtained, it was found that there was no significant difference between the two gamification methods regarding the overall performance of the students. In addition, there was no significant difference between the two gamification methods in terms of the level of difficulty of the questions. This demonstrates that no statistically significant difference was detected between the use of DualColor and PInteger gamification in teaching integers regarding overall post-test performance.

DualColor performed slightly better than PInteger regarding the overall achievement and achievement at moderate and HOTS question levels. However, the difference was not statistically significant. This demonstrates that the effectiveness of gamification should not be assessed based on the type of learning material used but on the basis of opportunities created for learners to explore mathematics through visualization and manipulative activities. Through gamification, the students were able to engage with the concept of positive and negative integers.

Furthermore, the results indicated that overall students' performance was better for easy and moderate questions compared to HOTS questions. Such a result emphasizes the problem associated with the development of higher-order thinking skills in mathematics even in the case when interactive methods are used. Hence, although gamification can enhance concept formation and motivate students, additional training and learning are still required to increase their reasoning and problem-solving skills in mathematics.

From an educational point of view, the research results give evidence that both DualColor and PInteger gamification can be incorporated into regular learning without any complicated technology or costly materials. It is up to mathematics teachers to use either of the gamification techniques depending on the availability of materials and the goals of the learning process, while still ensuring a student-centred

learning experience. Thus, the developed by teacher gamification tools proved that even simple visualization materials can help to learn complicated mathematical concepts.

Moreover, the results of this study can also be seen as further validation of the ideas behind Constructivist Learning Theory. This theory stresses that students learn by engaging in their own activities, exploring things themselves, and interacting with teaching aids. Since the gamification used in this research allowed participants to interact with and manipulate visual representations of operations involving integers, the gamification technique used helped students develop conceptual understanding rather than memorize rules.

It needs to be pointed out, though, that there are some limitations in this study, mainly its small sample size, the one-month period of its conduct, and the use of only one secondary school for this research. Therefore, future research may enlarge samples and a longer implementation period. Moreover, future research could also address the effect of gamification on other variables like learning motivation, mathematics anxiety, and student engagement.

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