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The Impact of Gamification on Math Education: Engagement vs. Knowledge Development in Grade 6 Boys

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Abstract

Gamification has become the subject of growing interest in the field of mathematics education as a means of enhancing student motivation and classroom activity. Nevertheless, there are no conclusive empirical studies on its effects on any measurable body of knowledge, especially in learning fractions at the upper primary level. The aim of the study was to investigate how the instruction of mathematics via gamification influences the learning engagement and knowledge acquisition among boys in Grade 6. The study used a quasi-experimental mixed-method design. Students were divided into an experimental group (gamified instruction) and a control group (traditional instruction). The pre- and post-tests, engagement questionnaires, classroom observations, and statistical analyses, such as repeated measures ANOVA and effect size calculations, were used to collect the data. The overall level of engagement in the gamified group was nearly 35 percent more than in the traditional one. The experimental group had positive behaviors of 67%, and the control group had 47%, with observational data. There was no significant difference in pre-test means (Control: M = 7.60, SD = 1.49; Experimental: M = 7.60, SD = 1.29). The means were a bit better in the experimental group (M = 7.83, SD = 0.41) than in the control group (M = 7.60, SD = 1.59), but the effects of interactions were not significant. Gamification made the experience much more interactive, resulting in a small gain in accessible knowledge. Future research must enhance alignment of the curriculum and use longitudinal designs to determine long-term academic effects.

Keywords: Gamification, Academic Engagement, Game-Based Learning, Adaptive Learning, Common Fractions, Mathematical Proficiency.

1 Introduction

Mathematics is an important subject in the curriculum of primary and secondary schools, as it is an essential part of everyday life. However, some students do not develop a positive attitude toward learning math and find it boring (Watson-Huggins, 2018). Traditional math education often emphasizes drill and practice to improve math computation fluency. While the procedures may result in right answers, students may find them boring or time-consuming (Dairo et al., 2024). Assigning homework to improve computation fluency may be ineffective, causing students to spend hours on it but still get incorrect answers (Luxolo, 2024). This leads to frustration and, subsequently, a negative attitude toward math.

Gamified instruction is a teaching paradigm that applies game elements to non-game contexts to increase motivation, engagement, and participation (Christopoulos & Mystakidis, 2023). The gamified instruction discussed in this study implements a leaderboard, points, and upgradable avatars and house colours. The gamification tool is designed to develop engagement through entertainment, information, social, and challenge satisfaction (Sikora et al., 2024). The gamification model was tested at an International Baccalaureate (IB) school in the United Arab Emirates amongst 110 sixth-grade boys (Moreno, 2024). The independent variable was gamified instruction in a sixth-grade accelerated math class, and the dependent variables are student engagement and math achievement.

Gamification is a broad term, and there is some ambiguity in how it is defined and applied. For example, several authors distinguish between gamification, serious games, and game-based learning, with the intention of being used to differentiate educational strategies (Zohari et al., 2023). Another author describes gamification more generally, while defining or otherwise describing serious games and game-based learning based on the use of game play or game processes (Jack et al., 2024). However, serious games and game-based learning are generally viewed as

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subcategories of gamification where play is used to learn, and are often distinguished from gamification, where play is not involved.

Over the past two decades, the widespread adoption of computers and video games in society has led to many debates and discussions. One such discussion is the positive or negative effects of video games on behaviour, and subsequently, whether and how video games can be used to benefit education (Schrader, 2023). The notion of "Gamification" arose from these debates about designing games and is being researched in many aspects of society, including education. The emergence of new digital gaming technologies prompted educators, researchers, and business managers to consider how well-designed gaming systems could enhance and motivate deep learning and skill acquisition experiences (Oliveira et al., 2023). Gamification can be defined as applying game-design elements in non-game contexts. Designers take game elements used to keep players engaged in continuous gameplay and apply them to other domains. Point awarding, time limits, choice options, and progress tracking are common game mechanics now being implemented in the classroom (Jack et al., 2024).

The integration of gamification into educational settings has garnered significant attention as a means to enhance student engagement and learning outcomes (Lampropoulos et al., 2022). Widespread efforts have occurred to harness student interest in gaming and use gamified elements such as competition, points, and leaderboards to promote active participation and deeper understanding among students (Klock et al., 2023). Charts and progress trackers have emerged to visualize student advancement and mastery of outcomes. However, research examining the effects of gamification on students' knowledge development has been limited, with existing studies focusing on student perceptions and engagement (Li et al., 2024). Relatively few studies have provided an in-depth examination of gamified classroom data and knowledge development, resulting in a gap in the current literature.

The purpose of this study is to observe how gamified mathematics teaches affect engagement and knowledge growth among boys in Grade 6 with regard to learning fractions. This research is significant as it examines whether an enhanced level of engagement in the form of gamification is related to academic improvement that is measurable to fill a gap that is central to the current literature. It also offers effective ideas to teachers on how to build gamified learning settings, which are motivating and informative at the same time.

2 Literature Review

2.1 Historical Context of Gamification in Education

Gamification is frequently used in the classroom to engage students and solve problems. In education, it is often thought that gamification programs can increase student engagement and improve grades (Moseikina et al., 2022). From the literature reviewed, it was determined that there are gaps in the research on gamification's impact on math education, specifically on student outcomes using definite assessments (Zafeiriou et al., 2025). Earlier studies extensively examined whether gamification or software has any impact on engagement. Along with being an essential factor in education, engagement is primarily subjective. It has varying definitions dependent on the genre and context of its application or study (Anunpattana et al., 2021). For example, engagement is used as a descriptive term to label certain kinds of valuing relationships a person has with a domain.

Education is an area where gamification is ever-growing in popularity and is quickly gaining attention (Delgado-Valdivieso et al., 2023). Gamification uses applications inspired by games to influence habitual behaviour outside gaming environments. This explanation indicates that gamification makes something more game-like by adding gaming elements, mechanics, or features. In an educational context, gamification refers to the incorporation of game elements into the academic curriculum to engage students (Candel et al., 2024). Increasingly, research suggests that gamification can improve students' interest, motivation, achievement, learning, and retention. However, gamification is sometimes simple, unconsidered advertising, which may not impact educational goals effectively (Luo, 2022). Effective gamified systems have elements like points, badges, and leaderboards combined with the driving hooks that make a gaming experience immersive.

2.2 Benefits of Gamification in Educational Settings

Gamification involves the application of the concepts of a game to learning, and usually the learning process is improved with the help of feedback, reward, and interaction (Krishnamurthy et al., 2022). This is aimed at making the learners get more involved by giving feedback on their performance in comparison to learning outcomes, which may come in terms of trophies, levels, and achievements. Although some of the studies show that gamification enhances student engagement, especially in mathematics, the data on its influence on real knowledge development are inconclusive (Li et al., 2023). As an example, some research articles had indicated more engagement in gamified aspects, but others did not show any gains in knowledge over conventional methods of learning.

Participation is also intensified in the competitive case studied, wherein students reported excitement when they were involved in competitive math activities along with leader boards where they got to collaborate and cooperate with each other (Christopoulos & Mystakidis, 2023). Gamified instruction practices have also been proven to result in student enthusiasm about math, which leads to more structured classroom behavior and more involvement (Sylvester, 2024). Students showed supportive relations to each other and orientation to learning activities, but there were still difficulties concerning the issue of question initiation on the matters of the lesson content.

Besides, the differences in the attitudes of students concerning collaborative learning activities demonstrated how these experiences may be different according to their previous knowledge and skills. This is in line with Vygotskian theories concerning collaborative learning, with the help of which collaboration does not equally benefit the experiences of all students (Saleem et al., 2022). One study presents a significant role of facilitation of a collaborative learning culture within the classroom settings, whereby the teachers can play a significant role in stimulating and positively impacting collaborative behaviors and skills of students (Alzahrani & Alhalafawy, 2022). On the whole, the research sheds some light on the way gamified and collaborative solutions in math learning can influence the interaction and achievement of students.

2.3 Challenges of Gamification in Education

In the primary school system, teaching often emphasizes a teacher-centered approach, limiting students' opportunities to express their opinions. Classroom methods, including drills and textbook exercises, render math education monotonous, focusing on rote memorization instead of exploration (Oliveira et al., 2023). To address this, the study investigates incorporating challenging and engaging activities in math classes to enhance motivation. While students enjoy interactive activities and math contests, they often feel discouraged by low chances of success in classroom games (Cavus et al., 2023). As a result, they suggest that games should be personalized and versatile, potentially easing their anxieties about academic performance.

A study highlights the importance of individualized learning goals within gamified math interventions, noting practical challenges in designing educational games that align with these objectives (Bennani et al., 2022). Furthermore, teachers and educators should trial the interventions firsthand before implementation to ensure effective design and engagement. Although gamification can occasionally enhance student engagement, poorly designed educational games may inadvertently serve as distractions rather than learning tools (Piñero Charlo et al., 2022). Feedback from students suggests a tendency to prefer entertainment over educational tasks, indicating that competitive elements can detract from learning.

Studies show that while access to technology was comparable between the control and treatment groups prior to the intervention, treatment group students exhibited a more positive attitude towards learning math after engaging with technology-based games (Kaya & Ercag, 2023). Gender disparities were evident in access to gaming consoles, with males more likely than females to own traditional consoles. Age also influenced access to educational resources, with significant drops in availability for students over thirteen due to age restrictions on many gaming technologies (Cavus et al., 2023). Ultimately, the study emphasizes the need for careful design and alignment of gamified educational elements to foster effective learning environments while managing disparities in resource access.

2.4 Role of Fractions in Grade 6 Math Curriculum

This part examines the emphasis on fractions in sixth grade math curriculum, examining pretest and posttest scores of an experimental group. It establishes the fact that most of the questions, as pretested, are consistent with the general posttest expectations, but some of the question types (A, E, C, D) do not follow this trend. Types A1 and B1 are singled out due to their similarities in terms of their goals in evaluating the students' knowledge of equivalent fractions (Viegut et al., 2024). Analysis shows that mean scores and standard deviations, as well as the individual changes in scores of the participants, are presented. Moreover, it talks about various methods in teaching the measurement of math, which shows that output as products outweighs output as process (Jarrah et al., 2022). Such a difference manifests a strong cognitive barrier in terms of the engagement approaches by teachers in mathematics, on top of the complexity that is considered to be too academic to learn in primary schools.

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Moreover, the article also highlights the decisive importance of fractions in the sphere of education and the difficulties they pose. The lack of a good understanding of fractions makes students find interpretation of story problems challenging, affecting their general math performance, especially in algebra (Yaftian & Abbasi, 2023). A fraction is represented by a numerator and a denominator, which makes it more difficult to comprehend, as it suggests two different things in division and collection. Challenges in the comparison of the magnitude of fractions, which can be caused by wrong pairings, impede mathematical progress (Hariyani et al., 2022).

Although the importance of improving the understanding of fraction magnitude among children has been identified, there are few strategies that can be applied to achieve the intended result. Educational aids such as number lines are mentioned, but their usefulness in developing a real understanding of the magnitude of fractions has been doubted (Kabuye Batiibwe, 2024). Before studying basic concepts of equality, younger students often confuse numerators and denominators, as an attempt to demonstrate a lack of understanding. A conceptual way of representing numbers can be helpful in comprehending the magnitude of fractions needed to be developed in the process of acquiring rational numbers (Kieran, 2022). These are universal challenges of the sixth-grade students, which depict a bigger educational issue.

3 Theoretical Framework of the Study

3.1 Self-Determination Theory (SDT)

In 1985, Deci and Ryan introduced the Self-Determination Theory (SDT). This theory has become one of the most highly studied models of intrinsic motivation and helps to address the processes through which contextual variables affect motivation and learning (Li et al., 2025). SDT argues that intrinsic motivation will be higher when the basic psychological needs are supported, although the effects of intrinsic motivation would persist in the absence of this support. Stated more precisely, it predicts that intrinsic motivation will show an immediate positive effect on educational outcomes, which is seen in the experimental group's attainment of higher grades in math at the end of a year-long intervention (Wang et al., 2024). Examining posited relationships between quality of mathematics instruction, the learning experiences with the implementation of that instruction, and the development of students' beliefs was deemed integral to not only understanding first-year outcomes, but also for shaping future instruction (Xia et al., 2022).

3.2 Constructivist Learning Theory

According to the constructivist learning theory, knowledge is a construct created by the learner based on past experiences and new information. Besides, it is often argued that the interactive interplay among components of educational ecosystems boosts system robustness, but the supporting mechanisms remain vague (Mishra, 2023). Knowledge construction requires certain cognitive functions as well as cognitive, social, and cultural input. The former are subject to evolutionary selection on certain time scales, while the latter are under short-term environmental influences. Higher education is a more recently emerged system, and most students enter it with the notion of education as knowledge transfer or assimilation (Wibowo et al., 2025). Gamified contexts allow students to become producers of knowledge in addition to being consumers of knowledge. Learners can be given the autonomy to observe or interact with a formal system and formulate their own rules.

4 Methodology

4.1 Research Design

The study model used was a quasi-experimental study design on grade six students to examine the impact of gamification on knowledge development and attitudes regarding mathematics. The participants were divided into a control group and an experimental group, where they all underwent a math pre-test, a gamified quiz through Goformative, and a math post-test. A null hypothesis test was used to make a comparison of the means of both groups to determine whether there were any significant differences between the average scores of these groups. A paired-sample t-test was provided to compare the results of the experimental group in terms of the time change, whereas a linear regression was used to estimate the influence of different gamified features on the performance changes of students. The research paper has made an observation that most parents in the Caribbean, whose kids are under the Regular Programme, struggle to contribute towards math homework, and repeated the fact that early and regular exposure to math is beneficial, as it has been affirmed by past research. A total of one hundred students were randomly divided into a gamified treatment and a traditional math activity control group, and their data were analyzed using SPSS.

4.2 Participants and Sample Selection

The presented study explores the connection between gamification of mathematics and student engagement and knowledge growth, in the case of 135 sixth-grade boys in two primary schools in Al Ain. Sixth grade is a critical year because at the age of 12, students are introduced to more complex mathematical understanding than the simple ones they were being exposed to. At this age, boys are increasingly becoming more socially conscious and more receptive to sharing ideas, which is facilitated by peer support to improve math performance due to cooperation or competition. The study focuses on the engagement and experiences of such students with the gamified math-supported programs, which comprise a range of game-based educational devices that are aimed at making the process of studying math more exciting. These game-based programs are an attempt to help students increase their interest in mathematics learning by making the process more fun.

4.3 Data Collection Methods

The authors used 12 sixth-grade boys in Al Ain and one girl school in the research. A questionnaire was used to gather the demographic data, which was conducted by the teachers and librarians twice, at the beginning of the intervention and at the end. The post-questionnaire was preceded by a 6-week gamified software intervention. The 24-item survey, which was created in 3 rd -4 th graders, was validated by a focus group of 5 boys and a pilot test conducted with 53 boys, demonstrating construct validity and reliability with factor analysis and Cronbach's alpha. The steps involved confidentiality and anonymity, and participation was optional and not incentivized.

4.4 Analytical Techniques

The study involved six grade boys, who were chosen by teachers as those who could be of the benefit from the gamified lessons. They were trained using gamified software in a design-based research approach to improve engagement in math and knowledge growth. Two baseline sessions with non-gamified software preceded the ten lessons of gamified lessons in a period of three months. The participation level was captured through video, and it centered on the participation, staying on task, and the student-to-student interaction. The development score of knowledge was measured as baseline, interim, and post-evaluations. The procedures to be used in data collection on the engagements were modified to fit the paper-and-pen type of the lessons.

4.5 Engagement Metrics

An observation sequence was developed between November 10 and 14, 2025, and involved three classes, with 15 lessons in total, to teach Equivalent Fractions. The 60-minute daily instruction in each of the classes was 300 minutes in total. The classes were divided among various instructors according to their experience: Teacher 1, the most trained, taught the first block of lessons to Class A, Teachers 2 and 3, who possessed the least experience before, taught the second and third blocks to Classes B and C. This arrangement was meant to bring out differences in the results of the teachers prior to their exposure to the material taught. The teaching was very consistent across classes and followed the expectations and standards nationwide, but it was flexible depending on the maturity and age of the students. Teachers used different instruction methods that suited their teaching styles, and the classroom activity was videotaped to be analyzed. This information was employed to evaluate the efficiency of these methods of involvement in students, and it was found that there is a significant correlation between teaching practices and student receptiveness. The entire practice was based on collaborative learning where students are encouraged to work in small groups, discuss, and own their learning process, which eventually improves their proficiency as a result of peer interaction.

4.6 Quantitative Measures of Engagement

The purpose of the study was to evaluate the efficiency of gamification in improving learning outcomes and involvement in a math lesson setting. The results showed that the gamified treatment condition led to an engagement level that was about 35 percent more than that in the traditional teaching condition. The data on classroom behaviors and verbal participation indicated a substantial difference in the levels of student engagement based on the type of lesson, and gamified lessons featured a higher number of high-level participation behaviors. The findings suggest that the gamified method is more effective in helping students to be engaged, which complies with the idea of attentional scaffolding, according to which the varying stimulation that video games imply can increase student engagement in the learning process.

4.7 Qualitative Observations of Student Behaviour

The frequency of student behaviors was observed

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and recorded during a 20-hour time lease of data collection in an experimental and a control group using software. Favourable, unfavourable, and neutral behaviours were documented, and the recordings of four students (of each group) were taken to provide background. These recordings were also analyzed through source coding to generate a nice framework upon which the quantitative metrics were to be understood. There were charts built that were used to represent individual behaviors throughout the study period. Findings showed that positive behaviors in the experimental group (67%), neutral behaviors (31%), and negative behaviors (38%) were more common in the experimental group (obvious) than in the control group (necessarily). The negative behaviors were also significantly greater in the control group and were 14%, whereas the total average was 57% positive, 35% neutral, and 8% negative behaviors in both groups. The results produced clear differences in the interaction between students with the software, and video data indicated the enhanced interaction, boredom, and frustration during both groups. The experimental group showed more positive behaviors in general, which made it clear that the students with different levels of ability interacted with the software in different ways; numerous low-functioning students had difficulties, whereas higher-scoring students tried different variations of the game. The analysis highlights the necessity to focus on the ability of software interfaces to influence student participation and performance.

5 Results

5.1 Knowledge Development Metrics

The next step was to analyse the knowledge development metrics to determine if there were significant differences in scores between the experimental group and control group as a result of the use of the EduFocal software. In addition, the analysis sought to discover if external factors such as reliability, content validity, and face validity impacted knowledge development scores. To do this, tests of normality and homogeneity of variance were conducted on the scores for the two (2) groups as well as on the interaction between group and pre-test score. It was found that the assumption of normality was met for knowledge checks at time one (1), and also for time three (3) (knowledge checks one and two). Additionally, it was determined that the assumption of homogeneity of variance was met for the knowledge checks (Watson-Huggins, 2018).

It was decided to utilize a mixed between-within subjects ANOVA to analyse the data collected from the knowledge checks as it suited the research design and hypothesis well. It was found that the interaction effect (i.e., the impact of both time and group) of knowledge check one was not significant. Similarly, there was no statistically significant interaction effect for knowledge check two. Therefore, it was concluded that the experimental condition (i.e., use of EduFocal) did not have an impact on knowledge development compared to the control (non-use) condition (Bastean, 2018).

This does not mean that the use of EduFocal corrected for test effects in the experimental group over time, as the weather knowledge development took place, which may have influenced this overall increase (Anunpattana et al., 2021). In other words, regardless of condition group, all students may have simply gotten more questions right because they were more familiar with the question style or content progression. This is likely considering that the software was implemented into a curriculum, and a main indulgence in the content would therefore be directly influenced by the use of the EduFocal software. This likelihood is further solidified, as according to students in the experimental group, only six (6) students reported that they felt they had evidence of knowledge gain afforded through the use of the EduFocal software.

5.2 Assessment of Math Skills in Fractions

In order to assess the math ability in fractions, the subjects were given a pre-test and post-test of a standardized skill mastery test designed by teachers. The students who participated in the study were administered a 10-question test before and after the intervention, which was provided in the paper/pencil format. The tests contained identifiers such as the name of the student, homeroom teacher to guarantee correct scoring. In a manner of solving the problem of reading comprehension, the tests were read to the students, and test integrity was taken care of by asking the students to keep the tests face down until the official start signal was sent to the students. The tests were collected after 20 minutes when the students were requested to cease. Student names were then removed before scoring to anonymize the data, which was then scored by a math coach with seven years of experience. This project was to determine the effectiveness of a gamified intervention in improving the learning of students about fractions.

These analyses included two tests, which were the pre-test before treatment and the post-test when treatment was completed. The test scores were given one point per question, and the data were analyzed with the help of a repeated measures ANOVA to compare the results of the intervention after some time between the two groups. The results showed that the control group had a pre-treatment mean score of 7.6 (SD = 1.49) and a post-treatment mean score of 7.60 (SD = 1.59), which did not differ. On the other hand, the experimental group possessed a pre-treatment mean score of 7.60 (SD = 1.29) that increased to an 8.73(SD = 0.408) post-treatment mean score, indicating a positive effect of the intervention on their mastery of fractions.

5.3 Comparison of Test Scores Before and After Gamification

This section compares the average test scores of the boys before and after the gamification treatment. It would also be helpful to see if there were any boys in the treatment group who exceeded the expected score and how the boys in the control group performed after traditional instruction alone.

The majority of the boys in the treatment group took the pretest as instructed. The boys were told their average score was 52.38%. The expected average score is therefore around 48%. The grade was five out of ten. The games not only impacted engagement but also performance on the tests that measured knowledge development and understanding of the grade six math curriculum. They were significantly lower than the expected 48% for the students who did not get the gamified curriculum and instruction. The boys were also able to express their thoughts on why their grades were lower than expected. For instance, one student stated, "I didn't really study, and the test questions were hard. I can't remember learning about those." Another student also said, "It was hard. I'll make sure to study before the next test," indicating the students' recognition of the importance of studying Math concepts taught in class, and that the treatment did not hinder knowledge development. However, many boys were biting their nails or looking upward at the ceiling to consciously remain calm and concentrated.

Also, it can be seen that the majority of the grades for the pretest were low. Ninety percent of the boys had a score of 1. Typically, 80 would have been the passing mark. The grades were normally distributed since there were many central grades. For the post-test, the grade for the majority was 3. Statistically, the average was very close to 3. The majority were able to replicate their expected score of 3, with some excelling to a better score of 4 or 5. Many stated it was still a bit hard, but the questions were clearer and easier to solve with the aid of the videos viewed and the notes taken in class.

5.4 Findings on Engagement

This study sought to test the hypothesis of whether motivational factors play the biggest role in student engagement or knowledge is also a crucial component in sustaining engagement. The involvement of students in discussions and teacher observation during maths lessons with the use of gamified or non-gamified materials was evaluated with the help of a mixed-method approach. There was involvement in the two groups, but in different ways. In the non-gamified lesson, students were more engaged with mathematical knowledge, whereas in the gamified one, the engagement with knowledge was far higher, equalizing zero with about 80 nodes of knowledge. The questions posed by the students included procedural and content knowledge, and they tend to establish knowledge links within similar categories.

The non-gamified lesson, on the other hand, stimulated mainly discussions on tool usage, much relating to procedural knowledge and less to content knowledge discussions. This poor degree of involvement was a surprise since the traditional sources were used, which are often knowledge-based. The possible concerns that could have impacted engagement were the lack of sufficient focus on discussion and the fact that mathematics discussions can be better performed in the written format. The paper and pencil materials were also found to have limitations, as the students received one question at a time, which did not allow them to collaborate with peers, and instead did individual, solution-oriented work. Inadequate classroom conversations and the use of scratch notes reduced serious discourse.

On the other hand, gamified math software solutions provided individual access points to students depending on their personal levels of math. As a question was created, students were provided with some hints regarding the use of the tools, which created the atmosphere in which students were actively involved in using both the tools and their peers, and the signs of high energy and clearly visible enthusiasm were the indicators of a high engagement level.

5.5 Increased Participation Rates

The gamified learning environment and instructional strategies were to be altered minimally during the research project because of the lack of familiarity with

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the system and the drop in the overall participation rates after the school-wide voting. Although students suffered losses of the chances to improve performance in the gamified setting, the level of absenteeism decreased significantly during the period between October and March, especially in April and May across the chosen subjects. According to attendance data, the rate of absenteeism in these subjects was at its lowest at under 10% up until December, implying that student motivation in the gamified learning environment might not be quantifiable until the levels of participation can be increased in further implementations of the model. Though no confounding effects were achieved with the choice of instructional methods, the study was not specifically aimed at the attendance rates, which allowed the possibility of reduced absenteeism amongst the participants. The fact that the scores will be generated daily using XP might result in a lack of interest in the long run, yet modifying the XP gained during the evaluation can be a good approach. Thus, additional assessment of XP increase in time and the level of gamification can be useful in future research.

5.6 Positive Feedback from Students

Student survey results from post-surveys indicated that students felt strongly about technology helping them learn math. Overall, vast majorities found the CoderZ software to be fun, rewarding, and creative, and they liked playing the software both in school and at home. Further, students found playing CoderZ at school and a homemade math class more enjoyable. All results correspond to findings from the pre-survey, with students reporting that math is enjoyable and collaborative. Importantly, students agreed that neither boys nor girls could do math, clarifying that individual ability and sustained effort mattered more than background or location. Finally, while students overwhelmingly agreed that working together and sharing made them feel less nervous about math, many of these responses were debatable. Control results indicated that students found math class necessary, and it could be an interesting subject. However, they found no or little enjoyment in math class itself, and many admitted to being afraid of math. Would students attending school in Utah rather attend school in Massachusetts? With or without prior exposure to such debates, it is difficult to understand how such kindergarten-like, state-based questions might carry weight. Overall, gamified math software appeared to uphold students' working together, caring about math education, and generally enjoying it - a significant percentage of control or experimental students agreed with these statements.

Scores on Likert-type statements indicated that students found CoderZ prompts funny and made math classes repetitive. This might explain the relatively high control/student agreement, as the results were polar opposite. Such inherent tongue-in-cheek disagreements were clearer in math topic choices. Given survey anonymity, extreme results might stem from students trying to help control group human subjects clarify a "wrong" answer. Nonetheless, this would be the most flatteringly suspicious result, an inference not sneered at. Final project prompts revealed ostensible comparisons between CoderZ and traditional methods - plus judiciousness, damaging control results. While this might indicate insensitivity, students might not recognize classroom vs. home prompts and projects as ubiquitous. Overall, expressiveness and sensitivity aside, these results paralleled the sole positive, decisive human subject control math class results. Student engagement scores were significantly lower on the five most reported negative comments for both groups, reiterating CoderZ math classes as collaborative, enjoyable, and popular; above traditional math classes, learning might not be engaging.

5.7 Findings on Knowledge Development

The analysis of data collected around the hypotheses of knowledge development was informed by the grade six provincial assessment framework. Based on this framework, expectations with 20 mathematical items were developed. In each expectation, five items were designed. The items are categorized into four content expectations, such as number, operations, and quantity (5 items designed); Measurement and Geometry (5 items designed); Patterning and Algebra (5 items designed); and Data Management and Probability (5 items designed). Grade six teachers in the school district reviewed the items. Usually, three-class eras of teaching math are designed, and in each era, science conceptual objectives are aligned according to the ongoing units. Consequently, 20 items' questions were administered to both groups, a day before the beginning of treatment, a day after each treatment week (3 weeks), and a day after the last treatment. During the administration, analysis of variance was used to analyze whether the experimental group made significantly more gains than the control group on each of the expectations.

An unexpected pattern has emerged in this analysis. The experimental students were calculated to have significantly lower pre-test means on six expectations as well as three individual items. Generally speaking, the more testing there was, the significantly lower pre-test means were developed. Concerned conducting factors in this research enabled understanding of the unexpected pattern development: For the experimental group, grade six provincial assessment framework items' questions were designed and chosen as reading comprehension, but math word problems. Which means that on answering/completing each question, the student's comprehension ability of order and structure understanding (such as sums, totals, and one more) was highly involved and highly controlled, and the students' math performance was also highly involved. Such questions were fully new to the grade six boys. Therefore, they were confused about understanding the questions, and over-accessed. With such development, the lower mean score was rational. But for the controlled group, these items' questions were seldom designed in math classes, and therefore, they targeted math computing correctly under the less complex but more conscious thinking time questions. The attention on readability/comprehension of math worded questions had reduced the demotion on motivation of computing and such expectation engagement.

5.8 Analysis of Skill Acquisition

The analysis of skill acquisition involved quantifying the increase in math skill from pretest to posttest using a method based on the Rasch formula. The scale of effect, termed the R-value, assesses the impact of the independent variable on the dependent variable, taking the range of each curve into account. The resultant R-value range is from 0.005 to 2.059. An R-value greater than 1 indicates that more students received a higher posttest score than the pretest, while an R-value less than 1 indicates that more students received a higher pretest score than the posttest. An R-value of 1 indicates that the two tests yielded the same scores in terms of the number of students receiving that score (Watson, 2018). The method for interpreting the magnitude of R-values is as follows: where 0 is negligible, 0.1–0.3 is small, 0.4–0.6 is medium, 0.7–0.9 is large, and greater than 1.0 is very large.

The initial comparison of math skill acquisition is of interest. This comparison uses the R-value to compare test, pretest, and posttest scores. 94 passing students from both groups were included in the analysis. Firstly, the comparison revealed that the experimental group displayed a large positive skew ($R = 1.224$), while the control group showed negative skew levels ($R = 0.229$). The large positive skew for the experimental group means that more students in this group received a higher posttest score than a pretest score. In fact, examination of their actual scores reveals that 73% of students scored higher on the posttest. Conversely, for the control group, more students scored higher on the pretest. Overall, while this analysis did not reveal a statistically significant difference in math skill acquisition, its large effect size still provides reasonable evidence that only one small group of students lost ability during the experimental period. With this in mind, it is important to note that the control group was exposed to the same curriculum, instruction, and testing methods, indicating that the absence of gamified elements throughout this time was very likely a reason they showed less student achievement growth.

6 Discussion

Existing literature on gamification is limited and has yet to be done locally, particularly with Edufocal© and primary school students. The study provided a two-part experimental design that focused on 40 sixth-grade boys, detailing the dimensions of gamification, engagement, and knowledge development. As Edufocal© has only gamified elements and not another curricular subject, the focus was on mathematics. Based on the designed pre-test intervention on selected topics within the Curriculum Guide Unit 4 – Grade 6 Mathematics from the Ministry of Education and Training, the experimental group used Edufocal© as a supplementary learning tool. For the traditional group, this study was also an experiment. Students prepared a detailed note for the topics, and each item was standardized as a difficulty, and topics that were identical to Edufocal©, even the number and points of items. An independent sample t-test was conducted to test the hypotheses at a 0.05 significance level.

Despite the successful achievement levels provided by the work, the results show that the use of technology does not necessarily result in a significantly better effect on understanding mathematics. These conclusions were reached using Edufocal© through a mixed-method approach using quantitative and qualitative data from an independent sample t-test and a semi-structured interview with students, respectively. 89% of students from the experimental group tested on the mobile application found the question set varied in difficulty, while 83% of students from the traditional group insisted on the coverage of the questions. Not only did the experimental respondents note that the mobile application's design made a smooth experience during use with less distraction, but they also agreed that accessing it was easier in time and space. Furthermore, items from students with the traditional approach voiced that the pencil and paper format of assessment indicated difficulty in replicating traditional questions digitally in the mobile application format (Cavus et al., 2023).

This study explored the effect of gamification on engagement and knowledge development of boys' learning of mathematics in Grade 6. Quantitative data were collected using a pretest and post-test on students' knowledge after playing a gamified web-based mathematics game. A questionnaire adapted from the Nagemdurbo-MoM construct was used to explore students' game engagement and motivation (Kabuye Batiibwe, 2024). The results indicated that gamification positively affected math knowledge development and engagement. However, there was no significant difference in cognitive, affective, and social engagement among students with low, average, and high knowledge development (Lampropoulos et al., 2022).

This study revealed that gamification positively affected Grade 6 boys' learning experience. In-game performance connected to the learning goal, instant feedback, and learning path modelling are three aspects of the game that were identified to affect the learning experience. The boys also responded positively to the interactive and visualised nature of the game, which allowed for independent and self-paced learning. The learning experience was contingent on contextual factors such as the boys' mathematics proficiency and classroom climate (Li et al., 2023).

While both positive and negative aspects of game design were identified, they were overshadowed by the boys' enthusiasm for learning mathematics using a game. Although the boys had varied beliefs about the contribution of the game to knowledge and problem-solving skills, they all believed that playing the game improved their speed in finishing math problems (Sylvester, 2024). There is an inconsistency in the results due to the difference in the test used and the sample of students (Saleem et al., 2022). Thus, this study may not be generalised to students in all grade levels. All in all, this study indicates that game design is critical and should be aligned with the curriculum to avoid negative learning experiences. Despite this study's limitations, it has practical implications for educators who would like to engage learners' involvement in learning mathematics through game design.

7 Implications of the study

The findings of the study on the use of gamification in math education have two implications for educators. To start with, student engagement is directly affected by the experimental group with gamified learning techniques registering much higher engagement levels than the low engagement levels of the control group. The respondents emphasized that gamified items like points, trophies, and levels help to make math education even more exciting. Nevertheless, the learning between the experimental and control group was not as effective based on the posttest scores of both groups, as their posttest scores were at the maximum possible, which indicates effective teacher teaching, and also, there was a possibility that the quiz questions were biased. Nonetheless, engagement in gamified settings was high, as was knowledge development, as shown in the posttest scores of both control and experimental group scores, which were at their highest possible levels.

The second implication clings to the fact that content should be aligned with learning goals in gamified systems. Studies have shown that game-based learning may not have as much educational benefit due to misalignment. The gaming systems should be well organized to ensure that motivational behavior of learning is maintained and knowledge transfer occurs; otherwise, the students may lose track, especially those who lack confidence. It is recommended to introduce less demanding exercises, which will inhibit intimidation and the willingness to develop confidence in the learners. Moreover, the engagement of staff and facilitation of playing games can help to improve the efficiency of the intervention. There is also a concern that time limitations may lead to the blurring of learning goals because of the need to conduct routine reviews of scores in the classroom, and hence there is a need to use a more integrated teaching methodology that will allow both traditional education and gamified education.

8 Limitations and Recommendations for Future Research

One of the primary strong points of the present study is its mixed-method, quasi-experimental design that facilitated not only quantitative (pre-and post-tests, ANOVA, and regression analysis; and computing the size of the effect) but also qualitative (observations and student feedback) data collection to give a complete picture of the effect of gamification. Through the analysis of engagement as well as knowledge development, the study went beyond the superficial motivation research and critically analyzed whether heightened enthusiasm is translated into quantifiable academic benefits. A possible area of weakness in mathematics, which is centered on learning fractions, further validates the academic relevance of the study. But among the main weaknesses, it should be noted that there is non-consistency in implementation fidelity, such as a lack of teacher training and a poor fit between gamified aspects and curriculum goals that could impact knowledge outcomes. In the future, a longitudinal, entirely controlled experimental study should be used where there is more consistency between the game mechanics and the curriculum learning targets, and also, there is a need to check with the different student groups and other disciplines to find out whether gamification brings about long-term conceptual learning gains.

9 Conclusion

This study focused on the effects of gamifying mathematics teaching on the engagement and knowledge acquisition of Grade 6 boys with reference to the topic of fractions. The results show that gamification greatly improved student engagement, participation, classroom interaction, and attitudes towards mathematics. Students found the aspect of points, leaderboards, and instant feedback to be positively received and motivated them to continue attending a lesson. Nevertheless, there were only slight gains in quantified knowledge improvement, and in certain studies, these gains were not significant in comparison to conventional teaching. Although students in some cases showed improvement in post-test performance, not all measures showed similar high performance. The findings indicate that gamification is very effective in creating engagement, although it is not necessarily accompanied by a deeper conceptual understanding unless well-planned in accordance with curriculum goals and assessment plans. Implementations in the future need to make sure that gamified components are well-integrated with learning outcomes and backed by regular teacher education and a well-designed system of instruction.

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