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Impact of Gamification Based Formative Assessment Tasks on Higher Order Thinking Skills and Motivation

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Abstract

Gamification-based formative assessment practices create opportunities for students to ensure an interactive learning environment with prompt corrective feedback and monitor their performance. True experimental research with pretest-posttest control and experimental design was used to investigate the research. The target population contained 248 students of class 5 enrolled in ten government schools in district Astore. Data was collected from students using higher-order thinking skills pretest-posttest and motivation pretest-posttest scale tools. Experts ensured validity and reliability through pilot testing. The results revealed that there is a substantial difference between the experimental group's higher-order thinking skills compared to the control group. Besides, the Wilcoxon Signed Rank test also described that the experimental group's motivation level is high and significant, whereas the control is statistically insignificant. Hence, it highlights the positive impacts of gamification-based formative assessment tasks on students' motivation and higher-order thinking skills in terms of mathematics teaching. The results of the research recommended that gamification-based formative assessment practices must be integrated into the teaching of mathematics at the primary level to ensure prompt feedback and monitor performance. It also provides opportunities to improve higher-order thinking skills and motivation and reduce ethical pressure carried out due to conventional assessment. The results of the study may be used to monitor students' performance regularly, which provides a unique opportunity to assess the effectiveness of teachers' instructions. Further research studies may be explored with a longer intervention period on gamification-based formative assessment of higher-order thinking skills and motivation using a mixed-method research design.

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Introduction

Since the 21st century, the greater use of technology in education has promoted the learners as the key attention, where technologies play a central role in improving learners' engagement and learning achievement. Besides, in the last decade, tremendous interest has been shown in using gamification in learning environments to improve student learning engagement, motivation, and cognitive skills. One of them is the tool of gamification, which contributes to make the learning space interactive, personalized and competitive. For instance, the Kahoot learning platform based on game-oriented solutions has received extensive popularity in schools for using opportunities for immediate assessment and feedback (Wang & Tahir, 2020; Balaskas et al., 2023). Kahoot application helps in promoting group cooperation, enhancing learners' motivation, as well as improving mental abilities through gamification of learning assessments and making learners feel more engaged (Aliyu et al., 2022; Arif et al., 2019). By engaging its speared features, Kahoot enhances not only the interaction but also the learning process, especially in mathematics, where students are seen to face motivational and compliance challenges when teaching (Jarrah et al., 2024).

Kahoot game-based tools enhance self-regulated learning critical thinking and result in improved performance, according to (Nadeem & Alfalig, 2021; Mao et al., 2022). In particular, Kahoot has been employed at different levels of learning stages to enhance achievement in different learning areas that include but are not limited to mathematics, critical thinking, and problem-solving (Irawan & Latifah, 2023; Jauhari et al., 2024). However, while the literature on the effectiveness of Kahoot gamification is expanding, its use in primary education and mathematics needs to be better covered in the literature. Mathematics is one of the learning areas in which the learner needs to apply both lower-order thinking skills and higher-order thinking skills to students, such as problem-solving, analysis and creative skills. Several research studies reveal how game-based learning can help the achievement of higher-order thinking skills in learning, especially in university education (Kartika, 2023; Kollo et al., 2024). However, the role of implementing gamified formative assessment tasks using Kahoot's results of the current study on primary school students' HOTS and motivation in mathematics is uncovered. This gap thus requires studies that analyze the prospects of using game-based formative assessments for improvement of academic performance, analyzing and refining students' critical thinking abilities, and improving young learner motivation levels.

However, Rosidah, Putra and Hendriana (2024) and Malak (2024) studies on the effectiveness and engagement enhancement of Kahoot to enhance academic achievement but lack of analysis of the longer-term effects, such as the creation of critical thinking skills, especially not focus in primary level students. Another distinctive feature of the study is the use of formative assessment tasks within the context of the gamified environment, which were not focused in the primary school mathematics context and still need to be adequately examined. Besides, Rayan and Watted (2024) and Kollo, Bani, and Mahfud (2024) investigated the effect of Kahoot in terms of higher education students' critical thinking and elementary science education students' critical thinking; no prior studies have focused on how the gamified formative assessment can promote HOTS and motivation in mathematics learning at the primary level. Warsihna et al. (2019) applied Kahoot-based intervention for coordinating and enhancing undergraduate psychology students' academic achievement and critical thinking; however, it was conducted in higher education settings, and the impact of Kahoot-based learning on primary-level mathematics learning or for younger students, has not been investigated.

In addition, Aibar-Almazán et al. (2024) investigated the effect of Kahoot on increasing students' attention, creativity, and critical thinking abilities of university students. This research was focused on the higher education context and the longer use of gamification, whereas there is a comparative lack of knowledge. In his study, Lee (2023) proved that using gamification with different teaching approaches improved the learners' creativity, teamwork, and interpersonal skills among university students. In Jaramillo-Mediavilla et al. (2024), it was clearly observed that the use of gamification enhances the amount of motivation and performance among students in learning by enhancing cognitive learning, self-learning and collaborative skills. However, this review was more general in terms of educational application. It did not investigate how tools like Kahoot influenced the learning cognitive skills and motivation of primary school students in subjects for learning such as mathematics. Kapsalis et al. (2024) also noted that Kahoot was suitable for use as a form of formative assessment in the foreign language classroom with regard to the improvement of grammatical comprehension. However, this study limited itself to concerns of adult learners and grammatical features of foreign languages, which is a preliminary to understanding the effects of Kahoot on primary school students' cognitive skills and motivational disposition toward teaching.
While several benefits of gamification deal with student's motivation and interest levels, effective procedures for cultivating HOTS, such as in the context of mathematics, still pose a problem. Past-present approaches to classroom learning and testing have failed to foster the necessary thinking abilities through mechanical learning and retention that inhibit effective solution-finding abilities (Akcaoglu et al., 2023; Yanuarto & Romadona, 2021). Research has revealed that poor or less effective models of assessment do not foster the development of thinking skills, hence disempowering students and resulting in learning failure (Hendriawan, 2019; Deklerk & Kato, 2017). In this context, formative assessments in the form of gamification, especially on the Kahoot platform, can provide an answer. Through instant feedback and encouragement of effective learning, Kahoot can improve HOTS and student achievement in mathematics, as shown in (Rayan & Watted, 2024; Hwang et al., 2022).

The literature review highlights the use of Kahoot in other learning environments. However, its use in the context of primary school mathematics education is inadequate, with little emphasis on both lower-order and higher-order thinking skills. Jauhari et al. (2024) and Irawan and Latifah (2023) described the improvements of HOTS using Kahoot. However, in other studies, such as Rahim et al. (2024) and Jarrah et al. (2024), Kahoot increases students' motivation and achievement but focuses on lower-order thinking skills. These studies were only specific to lower-order thinking skills, and they did not cover the impact of higher-order thinking skills. Furthermore, the above studies also suggested conducting impacts of Kahoot gamification on higher-order thinking skills among primary-level students. However, the above-noted research studies only targeted higher education or secondary education. It did not consider how gamification tools like Kahoot would affect primary school students' motivation along with their higher cognitive skills focusing on mathematics.

Moreover, the use of traditional assessment practice reinforces test anxiety, which consequently hinders students' cognitive skills and learners' capabilities of being able to perform well (Deklerk & Kato, 2017). Hence, students feel anxiety and stress; they are also unable to utilize their higher-order thinking skills. Consequently, students cannot think about inventions and discoveries, which is impossible because of anxiety and stress. To provide a valuable environment to students while delivering lectures with motivation, gamification-based formative assessment practices are essential to ensure immediate feedback and monitor instructions effectively. Different related research studies were found in the literature, but more evidence regarding gamification-based formative assessment and higher-order thinking skills and motivation toward mathematics was needed. More research is essential and crucial to determine how gamification-based formative assessment affects students' higher-order thinking skills in mathematics and their motivation. This study aims to reduce these challenges by investigating the impacts of using Kahoot-based formative assessment of higher-order thinking skills and motivation in primary school mathematics classes. Therefore, it seeks to establish the impact of the use of gamification-based formative assessments in developing higher-order thinking skills and motivation of primary school students with a focus on mathematics. It is applicable since it examines the extent to which formative assessments set through gamification can improve higher-order thinking skills and motivation of primary school students in Mathematics. While there is a rising increase in interest in gamification, research about its effectiveness in primary education is infrequent, and even more so in subjects such as mathematics. Thus, the study will fill the gap to help educators interested in education innovations that improve higher-order cognitive skills and increase the motivation of children in mathematics teaching. It will contribute to extending the understanding of how and to which extent gamification of assessment tasks would be beneficial for enhancing not only cognitive skills but also keeping young learners motivated, thus increasing the usefulness of learning processes.

Problem of the Statement

The current formative assessment practices in mathematics for primary school students in Gilgit-Baltistan, Pakistan, face significant challenges. The primary issue stems from teachers' difficulty in providing individual feedback and monitoring student performance due to time constraints and large class sizes. Efficient feedback is crucial for learning assessment to aid and guide students in enhancing their work. Even with guiding principles, the problem of effective feedback remains complex (Elmahdi et al., 2018). Students need opportunities to correct misconceptions, enhance their abilities, and adjust their approach to assessment. If these issues are not addressed, it can lead to frustration and missed educational opportunities. The use of technology to provide feedback can significantly expedite the process, improve the clarity of communication, and foster a sense of individualized care and concern among staff and students (Hwang et al., 2022; Vrancken et al., 2021).

Due to the large number of students in class and restricted time constraints, providing prompt and individualized feedback to every student becomes more challenging and inaccessible. These strategies negatively impact attitudes toward mathematics and impede the development of higher-order thinking skills. The Board of Elementary Examination, Government of Gilgit-Baltistan, continuously faces disappointing results in mathematics despite administering a standardized regional exam based on SLOs (Board of Elementary Examination, Gilgit-Baltistan Result, 2024). The high number of students who either do not pass or get low grades indicates that students' higher-order thinking skills need to improve. According to Yanuarto and Romadona (2021), students' focus on memory instead of understanding is the root cause of mathematical problems. A 30-mark formative assessment and a 70-mark summative assessment make up the BEEGB assessment system. However, teachers cannot provide personalized assessments and comments due to the limitations of traditional formative assessments imposed by many students in class (at least 40 to 50 students) and short class periods (35–40 minutes). The presence of anxiety and stress among students causes the issue, thereby impeding their cognitive skills. Test anxiety significantly contributes to the poor performance of many children in mathematics, and teachers can overly depend on obsolete techniques for assessing student growth. According to DeKelerk and Kato (2017), the use of test anxiety and other traditional methods of assessment negatively affect students' ability to acquire knowledge. Mathematics studies are compulsory for primary school pupils. However, a significant proportion of students feel that mathematics is a boring, challenging, and uninteresting subject. To make mathematics enjoyable for children, teachers must demonstrate the methods and concepts (Setiawan & Soeharto, 2020). Hence, this study investigates the impact of gamification-based formative assessments on the development of higher-order thinking abilities and motivation in mathematics among 5th-grade students in Gilgit-Baltistan.

Objectives

1. To investigate the impact of gamification-based formative assessments in improving primary school students' academic achievement in mathematics, particularly focusing on higher-order thinking skills of the cognitive domain.
2. To examine the impact of gamification-based formative assessments on primary school students' motivation toward mathematics teaching.

Research Questions/Hypotheses

The following research questions and hypotheses were developed in order to conduct the study.

1. How does gamification-based formative assessment improve the higher-order thinking skills of the cognitive domain (analysis, synthesis and evaluation) of primary school students in mathematics teaching as compared to traditional-based formative assessment?
   H_1: Students who participate in gamification-based formative assessments in mathematics teaching show greater improvement in higher-order thinking skills of the cognitive domain (analysis, synthesis and evaluation) compared to those who participate in traditional-based formative assessment.
2. How does gamification-based formative assessment enhance both the intrinsic and extrinsic motivation of primary school students in mathematics teaching compared to traditional-based formative assessment?
   H_2: Students who participate in gamification-based formative assessment in mathematics teaching show higher motivation, both intrinsic and extrinsic, compared to those who participate in traditional-based formative assessment.

Literature Review

Theoretical Background

Gamification in education, a concept that has been gaining significant attention since its rise to popularity in 2010, holds immense potential to enhance motivation. While not a new idea, its increasing use in educational settings is due to its proven ability to support changes in attitudes and encourage healthy competition and cooperation (Garland, 2015; Tulloch, 2014). Originally used in domains such as marketing, training, and environmental conservation, gamification integrates interdisciplinary principles substantiated via theoretical and empirical research. The role of artificial intelligence in educational technology, particularly in individualizing and facilitating learning experiences, is of paramount importance and is a key area of focus for educators and professionals in the field (Garland, 2015; Tulloch, 2014). Various theories related to gamification are also discussed and analyzed, providing a comprehensive understanding of this innovative approach.

Operant conditioning, a core principle in behaviorism, may be used to comprehend the mechanics of gamification in educational settings. Rao (2013) described that gamification platforms that include user competition foster an environment where students may get incentives, such as points, for their accomplishments. By displaying scores openly, this kind of reinforcement may boost motivation by enabling students to see concrete improvement. However, this strategy may have disadvantages. Insufficient point accumulation among students might result in feelings of demoralization or embarrassment, which may ultimately lead to disengagement.

Moreover, punishing erroneous replies might deter students from engaging in difficult tasks out of fear of failure, which is a detrimental outcome of punishment (Irons & Buskist, 2007). Hence, while gamification may enhance motivation by using positive reinforcement, it is important to maintain a delicate equilibrium between incentives and punishments to prevent any detrimental impact on student engagement. Educators and professionals need to be aware of these potential challenges and the importance of managing them effectively.

The Self-Determination Theory offers a complete framework for understanding the motivating impacts of gamification. Baydas and Cicek (2019) propose that SDT asserts three primary psychological needs: competence, relatedness, and autonomy. Competence, the need to feel skilled and competent, may be improved in a gamified setting by including features like badges and leaderboards (Sailer et al., 2017). The need for social connection and relatedness may be promoted by enabling students to work together towards shared objectives, thus strengthening their feeling of belonging (Sailer et al., 2017). Supporting students' autonomy, which refers to their desire for control over their actions, can be achieved by offering them options in their learning activities. As Baydas and Cicek (2019) suggested, this approach can enhance their intrinsic motivation. By attending to these psychological demands, gamification has the potential to provide a learning environment that is more captivating and stimulating.

Flow theory, coined by Csikszentmihalyi in the 1970s, defines an ideal state of involvement when people are completely absorbed in activities with a feeling of pleasure and concentration. Flow is the state that happens when a task's difficulty matches a person's talents, resulting in clear objectives, quick feedback, and a feeling of expertise (Finneran & Zhang, 2005; Teng & Huang, 2012). When it comes to gamification, designing assignments that match students' abilities and offering immediate feedback may boost their involvement and foster more profound comprehension. However, accurate measurement of the flow state continues to be difficult, and further study is required to understand its comprehensive implementation in educational environments.

Cognitive Load Theory focuses on the constraints of working memory and its influence on acquiring knowledge. Kalyuga (2011) classifies cognitive burden into three categories: external, internal, and relevant. Van-Merrinboer and Sweller (2010) argue that well-designed gamification activities that prioritize key material may help minimize extrinsic load, which refers to extraneous information that obstructs learning. Sequencing activities correctly and providing scaffolding helps effectively manage the complexity inherent in the content itself, known as intrinsic load. The process of germane load, which is the incorporation of new information into pre-existing knowledge, may be facilitated via gamification by promoting active problem-solving and the practical application of ideas (Kalyuga, 2011). Although CLT has made major contributions to the comprehension of learning processes, it is crucial to urgently investigate its use of subjective measurements and its suitability in different educational environments (Dejong, 2010).

The research conducted by Senko et al. (2011) underscores the importance of balancing mastery and performance objectives in educational environments. Mastering objectives focus on competence development, while performance goals aim to surpass others. Gamification, as suggested by Kim et al. (2018), can be a useful tool for achieving this balance. By incorporating levels and leaderboards, gamification can enhance students' comprehension and abilities, and fostering can be useful in achieving this balance. By incorporating levels and leaderboards, gamification can enhance students' comprehension and abilities, fostering mastery objectives. At the same time, it can encourage performance objectives by including competitive features that inspire students to outperform their peers. However, it is crucial to maintain this balance to ensure that the competitive elements of gamification are consistent with the importance of learning and individual development.

The theoretical framework corresponds to the issue statement by addressing the challenges associated with traditional formative assessment techniques in mathematics for primary school children of Boys High School Gorikote Astore Gilgit-Baltistan. These challenges, such as the inability to provide immediate and personalized feedback, large class sizes, and limited class time, hinder the development of higher-order thinking skills and foster negative attitudes toward mathematics. This research study proposes operant conditioning, self-determination, flow, and cognitive load theory to develop a gamification-based formative assessment method. Their components are discussed above, and their relevance is also analyzed. This method can significantly improve student motivation, higher-order thinking skills, and engagement. By providing immediate feedback, promoting active engagement, and creating a dynamic learning environment, this method can enhance students' thinking skills and motivation in mathematics. The research examined the impacts of gamification-based formative assessments on students' higher-order thinking skills and motivation at a 5th-grade level in Gorikote, Astore Gilgit-Baltistan. The primary objective was to demonstrate how these assessments can effectively address the highlighted challenges and improve learning outcomes in mathematics.

Gamification and Motivation

The incorporation of games in education has attracted interest as a result of increased understanding that it boosts students' engagement and performance. When we talk about the activity integration into teaching processes, which kinds of gaming elements, for example, using a platform like Kahoot in educational activities, it is possible to help the learning process become more interactive and attract students' attention in the classroom (Zainuddin et al., 2020; Baydas & Cicek, 2019), these tools may also improve the student's attitude and behavior at school and thus set a new, promising stage of development in the field of teaching (Zainuddin et al., 2020). However, it is necessary to conduct more extensive research in order to establish the effects of gamification on motivation and learning outcomes for learners at various cognitive ability levels.

In Saudi Arabia, Alastair (2020) investigated the impact of gamification motives on learning in higher education. Though the use of gamification has indicated some positive impacts, it has yet to be a reliable variable that can predict motivation among students in the intermediate category. In the study, it was revealed that there is a necessity for further innovation in the overall process of utilizing games for plan enhancement, and further examination of multiple game mechanics and features was suggested. It has become important as we need more extensive research in different domains, including psychology, education, game design etc., about the effects of gamification on academic motivation and engagement (Alasmari, 2020).

Previous studies about Kahoot and Quizizz have revolved around their use in secondary and college institution students, showing positive impacts on motivation, performance and participation, specifically in English and mathematics. For instance, from the study made by Zulfa (2024), the use of Kahoot led to enhanced motivation, learning engagement, and cooperation in learning English for EFL students. Similarly, Akbarani and Pamungkas (2024) also focus on the use of Kahoot in English learning, which the students prefer and love since the tool is entertaining. Studies in mathematics also found positive impacts: According to Bakkali et al. (2023) and Jarrah et al. (2023), investigating motivation and academic achievement among secondary school students were enhanced by Kahoot for the university students, Kahoot was observed to increase interest and passion in learning in the context of higher learning especially in Mathematics as pointed out by (Pais et al., 2023; Pais & Hall, 2024).

Although these results are encouraging, literature on the application of gamification tools in the primary school context, and more specifically in mathematics teaching and learning, is relatively uncommon. Previous research has primarily investigated the attitudes of students toward learning English or attending a higher learning institution. Therefore, there is limited knowledge comprehensively describing the attitudes that pre and primary school students exhibit toward play-based learning (Zulfa, 2024; Bakkali et al., 2023). Primary students learning mathematics may require more attention, especially if they are in their early stages of learning mathematics as compared to older students; therefore, the above findings call for further research. Hence, further research is required to uncover how the use of Kahoot gamification may boost motivation and academic performance in Primary-grade mathematics learning.

Kahoot Based Gamification on Higher Order Thinking Skills

Literature on Kahoot also revolves around tertiary institutions, with research indicating that Kahoot increases student engagement, motivation and academic achievement. For example, Turan and Meral (2018) revealed that through Kahoot, students' performances were enhanced, students engaged more, and they were not stressed regarding lesson assessment in middle school in Turkey. The same trend persists in university environments, and

Kahoot has been shown to enhance the kind of mastery being pursued by university nursing students, particularly in English proficiency, reading comprehension and pronunciation (Yuruk, 2020). Furthermore, Gokbulut (2020) and Korkmaz and Oz (2021) underscore how prospective teachers enrich their teacher training by learning on the platform for online learning environments. University learners' critical thinking and problem-solving have also been noted among learners using Kahoot for extended durations. According to the studies done by Aibar-Almazán et al. (2023), the increased level of usage Kahoot has the potential to enhance learner's cognitive categories, including creativity and problem-solving Campillo-Ferrer et al. (2020) argued that Kahoot improved the students' share of social and civic competencies.

However, it is evident from the literature that unlike in higher learning institutions, more research needs to be conducted on the application of Kahoot in primary education with emphasis on the development of the HOTS, such as analysis, evaluation and creativity. The formal study conducted by Xezonaki (2023) examined the effects of Kahoot on preschool children's mathematical performance by analyzing increased scores in students' fundamental mathematic skills, counting and arithmetic. Subsequently, this study did not analyze how Kahoot promoted higher-order thinking skills linked to HOTS. Also, there is little literature available on the difficulties and constraints in the use of Kahoot while teaching and learning in the primary class, and HOTS was taught in math.

Although Kahoot has shown effectiveness in enhancing basic skills at higher levels, it has yet to be extensively researched on use in primary education to enhance the HOTS, particularly in the subject area of mathematics. Furthermore, there are still gaps in the literature pertaining to Kahoot in higher learning institutions, and research on the application of Kahoot in the teaching-learning process also bears some limitations; for instance, the research design (Fauziyyah, 2019; Rosiyanti et al., 2020). Lack of enough time, technical problems and inadequate teaching for both educators and students are potential challenges that have been made known by Alanazi et al. (2024). However, future studies are still needed to identify the implications of Kahoot in primary education settings. This would aid in determining to what degree Kahoot can be incorporated into math lessons for primary learners to support higher learning functions such as critical thinking and problem-solving.

Methodology

The study adopts a true experimental research design under the pretest-posttest experimental and control group design to determine the extent to which the use of gamification in the formative assessment of students' higher-order thinking skills and motivation. Based on the suggestion of Baştürk (2014), which mentioned that the pretest-posttest control group design could permit the direct comparison between the experimental group who experiences a games-based approach and the control group as a usual learning approach, the current study adopted the pretest-posttest control group design. This design provides a way to have a better cause-and-effect analysis since participants are split evenly into a Kahoot gamification group and a traditional assessment group. Random assignment has minimized selection bias, while the pretest establishes the basis for comparison with the posttest, which measures the effects of the interventional program. Using a random distribution of participants reduces the possibility of selection bias, thereby ensuring that any observed effects may be attributed only to the intervention and not to any pre-existing differences between the groups. The selected only ten schools as a target population based on reliable internet access and well-equipped laboratories allow for the effective implementation and assessment of the gamification-based formative assessment, facilitating the effective implementation of the intervention. Sources of variations that may influence the outcomes of the study, such as the time of the class, students' experience with IT, and teacher efficiency, were controlled to the greatest extent possible.

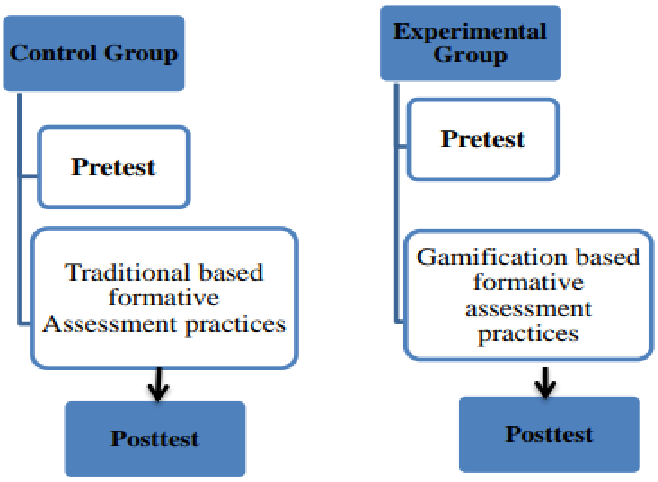

Figure 1. Research Design

Population of the Study and Sampling Technique

The target population was comprised of 248 fifth-grade students from 10 selected Government Boys' and Girls' Middle and High Schools of District Astore, and all the schools were located in the District Astore possessed with IT Labs and reliable internet connectivity, which was crucial to fulfill the criterion in implementing the proposed gamification platform. Boys High School Gorikote was chosen through simple random sampling out of the ten Schools. There were 54 students in the 5th class at this school. The researcher administered a pretest and later categorized the students into two groups based on their pretest results. In order to form these groups, the students' results were organized in descending order, and those with the same scores were grouped. The grouping procedure was subsequently conducted using a random selection method to choose names from the pairings. This selection procedure guaranteed that the creation of the two groups was impartial and preserved a degree of unpredictability in the selection process. This approach sought to improve the validity and reliability of the study findings.

Table 1. Population Framework

S.NO	Name of School	Class	Number of Students enrolled in 5th Class
1	Boys High School Gorikote	1 to 10th	54
2	Girls Middle School Gorikote	1 to 8th	22
3	Boys High School Bunji Astore	1 to 10th	25
4	Girls High School Chongrah Astore	1-10th	36
5	Boys Middle School Rattu Astore	1-10th	08

S.NO	Name of School	Class	Number of Students enrolled in 5th Class
6	Girls Middle School Rattu Astore	1-8th	11
7	Boys Middle School Tarishing	1-8th	06
8	Girls High School Tarishing	1-10th	13
9	Girls Higher Secondary School Eidgha Astore	1-12th	46
10	Boys High School Dashkin Astore	1-10th	27
Total Number of students			248

Sampling Procedure

Figure 2 shows the study's sampling design. The target population was 10 schools with 248 students enrolled in 5th grade; the simple random sampling method was used, and 54 students from Boys High School Gorikote Astore were selected. These students were subjected to a pretest, after which they were randomly assigned to two groups: An experimental group, which consisted of 27 subjects and a control group with the same number of participants. The experimental group completed a formative assessment in the form of a Kahoot game, whereas the control group completed a traditional formative assessment. Finally, each group conducted a posttest to assess the overall effectiveness of the assessment methods used during the interventions.

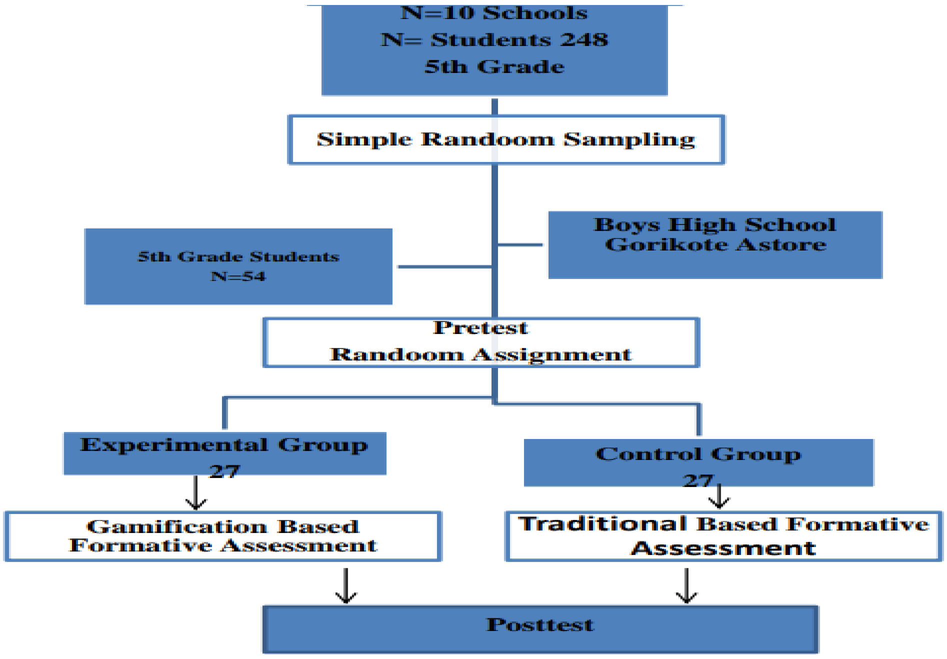

Figure 2. Sampling Framework

Procedure of Experiment

The study was carried out for eight weeks from October 20 to December 28, 2023, at Boys High School Gorikote Astore after getting formal permission from the Headmaster of the school. The conceptual framework of the Single National Curriculum for Grade 5 Mathematics was used to design 25 lesson plans for the experimental and control groups. These plans included formative assessment practices, particularly multiple-choice questions (MCQs), which had to be well-designed and accurately validated by content specialists to reduce the influence of unfair test bias. Experts also reviewed the same pretest and posttest questionnaires for content validity to ensure that the instruments were relevant to the study goal.

Prior to the intervention, the pretest used in this study was used for 54 students in the participating class to measure their learning and their basic cognitive abilities in mathematics before the start of the study. Hence, to obtain the equivalent status of academic aptitude, the students were grouped according to the scores obtained in the pretest. It was then possible to randomly assign one student from each pair to the experimental group (27 students) or control group (27 students). This approach helped in the reduction of bias and ensured that the formed groups had the same cognitive ability.

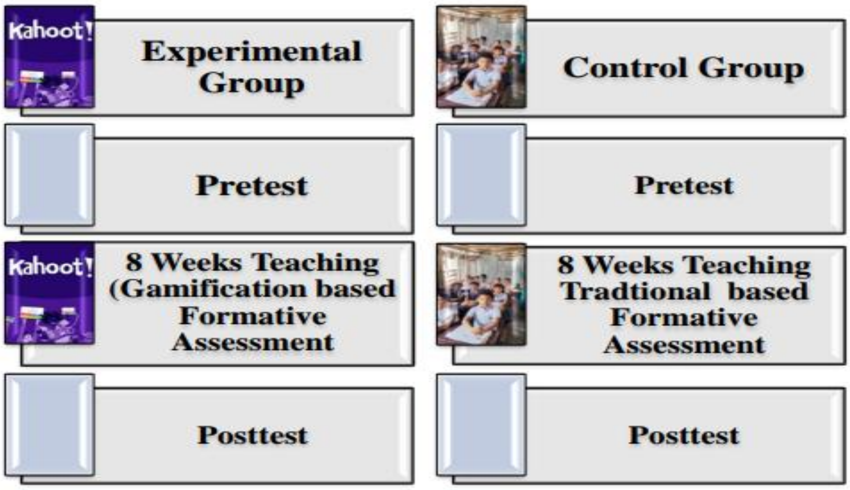

Figure 3. Intervention Procedure

To increase the likelihood of the experimental group's adherence to the intervention, that is, the use of the game Kahoot, all the participants followed an initial tutorial in the game before the intervention. As a result of this session, students had a one-on-one interaction with the platform and, therefore, met minimal technical hitches during the study. Both groups were then given standard lesson plans that incorporated higher-order thinking skills like analysis, synthesis, and evaluations, which were aimed at addressing the curriculum indicators as closely as possible.

Each of the lessons was taught and taken within a 40-minute timeframe. The lesson time was also split into three parts in order to be equal and effective for teaching, formulating assessments and providing feedback. The first 20 minutes included the presentation of the content of the lesson. The following 10 minutes were spent on a formative assessment of a lesson in which students had to complete 4-5 MCQ questions related to the stated lesson objectives. Last of all, there were 10 minutes for feedback. In the experimental group, feedback was given in the form of quiz results, with competition bar graphs as well as explanations of right and wrong answers, leaderboard, badges, scores, and immediate feedback given by Kahoot's stipulated system. Conversely, the control group traditionally received feedback and scores from the teacher, who gave lectures in oral or written form.

The lessons delivered to the experimental group were given before the school break, while the control group was given after the break. These schedules made it possible to have no interactions between the two groups and or contamination of results. The two groups were taught the same lessons, and the teacher ensured that he followed the lesson plan effectively in order to deliver the correct type of lesson. The questions given as part of the formative assessment and the content of the feedback were the same for both groups; the only variation was the approach taken; the experimental group received questions in the form of an online game, while the control group followed the usual way. Hence, to avoid biases and ensure that all processes used were fair, there was consistency, especially across the data collection phase. Students' lesson plans, assessments, and feedback mechanisms went through a process of expert review in order to control possible bias. The teacher educating the two groups recited the script at the same time to ensure the groups were receiving the same sessions. Equally dividing the time for teaching, assessment, and feedback for both groups made sure all students got the same amount of instructors' time, and the only difference was in the assessment feedback mode.

At the end of all 25 lessons, a posttest was given to both groups under controlled conditions. This kind of posttest was aimed at assessing students' academic achievement in mathematics in the context of higher-level thinking skills; it was administered and was identical to the one of the control group. The results obtained gathered from the pretest and posttests were used to assess the effectiveness of using gamification approaches for formative assessment of students' learning and motivation. This way, it became possible to compare the results of the experimental group with those of the control group in order to assess the impact of the intervention.

Data Collection Tools

Higher Order Thinking Skills of Pre-test and Posttest

The pretest and posttest were used to measure students' higher-order thinking skills in experimental and control groups. A pretest and posttest were developed from the Single National Curriculum (textbook) of mathematics subject class 5 by covering higher-order thinking skills (analysis, synthesis and evaluation). A Pretest containing 6 items of MCQs and 04 long questions was administered and also finalized after pilot testing in terms of measuring the higher-order thinking skills of students toward mathematics teaching.

Validity of Higher-order Thinking Skills Test

Table 2 shows the content validation index of the higher-order thinking skills mathematics test. Five experts contained two subject specialists, one Assistant Professor in AIOU Islamabad, Pakistan, in the Education department, and two elementary school teachers who taught mathematics subjects in 5th Grade in public schools, for validation of mathematics higher order thinking skills test that developed from the four units of mathematics subject of Single National Curriculum of Pakistan. The test contained 08 items of MCQs and 06 long questions. A content of mathematics subjects and a table of specifications were given to experts to validate the test appropriately and maintain its quality as well. The scale contained seven questions: Point Likert Scale 1 for Aligned, 2 for partially aligned, and 3 for Non-aligned for test validation. 04 experts were marked in the aligned option. In the long questions, three experts endorsed that the items measure high-order thinking skills, and 2 suggested some modification and marked partially aligned. However, items 3 and 7, given some feedback and suggestions by the 03 experts, were also marked in the partially aligned option—the test items incorporated as per suggestions given by the experts. The cognitive classification of two questions on the Higher-order Thinking Skills Test was revised during the validation process as a result of expert feedback. Question 3, which was initially listed under Bloom's Taxonomy (Synthesis level), was classified as an Evaluation. This required the student to find the least common multiple (LCM) of 15, 12 and 10, but the step involves finding the LCM and then stepping from that to selecting the correct answer; this is an Evaluation, not a Synthesis task. For example, Question 7, which was placed under the Evaluation stage by expert feedback, was moved to the Analysis stage. This requires students to break down the information and process it systematically to answer this question that involves basic arithmetic problems, such as multiplication and subtraction, and then the number of pencils and the number of red pencils. In light of these results, the updated classification of both questions best corresponds to the underlying cognitive processes. The researcher calculated the items-wise content validate index (I-CVI) and scale-wise validate index (S-CVI) through MS Excel. All the item numbers were calculated using the (I-CVI) 1. The scale-wise content validation index was calculated: 1. Hence, the calculated values of scale and item-wise content validation index are higher than the proposed value of 0.83.

Table 2. Validation of Higher Order Thinking Skills Test

S.NO	**Statements**	**Content Validate Index**		
		Aligned	Partially Aligned	Non-Aligned
1	The test items are made appropriately from the mathematics of grade 5th.	05	0	
2	The questions measure the higher-order thinking skills of students in mathematics subjects in 5th grade.	05	0	
3	The test is based on a table of specifications.	05	0	
4	The stems of multiple-choice questions give complete sense and meaning.	05	0	
5	Test items are according to the 5th-grade level.	05	0	
6	The distractors of MCQs are attractive.	04	1	
7	A sufficient time is fixed for the students to attempt the test.	04	1	
8	The long question leads to measuring high-order thinking skills.	03	2	

Motivation Questionnaire

The second instrument was the adapted Motivation Questionnaire, which aimed at determining the impact of the teacher's use of gamification-based formative assessment practices on students 'motivation. The questionnaire consists of twenty questions. This comprised ten items formulated for the students to answer before the intervention was launched and ten after the intervention was implemented. They were given three response options: Strongly Agree (SA), Agree (A), and Disagree (D). This questionnaire was developed by Darma, Agus, and Rosalina (2022) to measure Kahoot' for English subjects. It was modified to measure students' motivation in mathematics subject. The first tool used for learning English was modified for use in mathematics by replacing the word “English” with “Mathematics” and by including terms familiar to students and teachers in mathematics, including mathematical content areas, contexts, and practices relevant to traditional and gamified formative assessment practices (e.g., Kahoot). Furthermore, items were reviewed to fit the mathematical learning outcomes and motivational attributes so as to have subject relevance. For example:

> Original: "I enjoy learning English using traditional methods." Adapted: "I enjoy learning Mathematics using traditional-based formative assessment or Kahoot-based formative assessment."
>
> Original: "I am sure that using traditional learning is effective for understanding English content." Adapted: "I am sure that using traditional learning is effective for understanding Mathematics content. For the experimental group, a Kahoot-based formative assessment should be used instead of a traditional one.”

Validity of Motivation Questionnaire

The five experts and scholars, in a collaborative effort with the researcher, validated the questionnaire related to measuring the student effectiveness of the gamification-based formative assessment. The researcher, with the support and guidance of these experts, translated the questionnaire from English to Urdu by English experts to facilitate the students' understanding. It was translated into Urdu and validated by these five experts and scholars. All the experts were marked aligned option; only items number 1, 6, and 9 were partially aligned by the two experts with given feedback. As for Item 1, ‘‘I am interested in learning mathematics through traditional methods,’’ respondents suggested replacing ‘‘traditional methods’’ with the term ‘‘traditional assessment methods.’’ The difference is a more specific emphasis on formative assessment. In the same incorporation regarding Item 6, “Traditional way of learning mathematics can enhance confidence,” the term: “Traditional way” was modified to read “traditional assessment.” In Item 9, under “I feel happy learning mathematics through traditional methods,” It was proposed to substitute “traditional methods” with “traditional assessment methods” – it is more specific and clear; it was also recommended to substitute “happy” with more appropriate terminology such as engaged or satisfied, to specify the kind of emotions more accurately. Traditional assessment methods were thus incorporated into the item and came at the revised version of; ‘’I feel satisfied learning mathematics through traditional assessment methods.’’ These expert suggestions enhanced the reliability of the instrument to capture students’ motivation in a context that encompasses both game-based and traditional formative assessment procedures. The experts validated the questionnaire, and some minor changes were suggested. As per guided suggestions, the researcher incorporated the questionnaire and validated it, showcasing the power of teamwork in research.

Reliability of Higher Order Thinking Skills Test and Motivation

A preliminary survey was carried out at Boys Primary School Gairaki Gorikote and Ahmedabad to estimate the internal consistency of the Higher-order thinking test, which consisted of six MCQs and four long questions. The aim was to evaluate the comprehensibility and applicability of the items to measure thinking skills in students' contexts. The pilot test proved helpful in giving a sense of the final test and also collecting data to check reliability.

Table 3. Reliability of High Order Thinking Skills Test and Motivation

N of Items	Scale	Cronbach's Alpha
6 MCQs/1	High Order Thinking Skills Test	0.825
4 Long Questions	High Order Thinking Skills Test	0.762
10 Items	Motivation	0.892

Reliability analysis testing of the High Order Thinking Skills Test shown in Table 3 yields an alpha coefficient of 0.825 based on six MCQs and an alpha coefficient of 0.762 based on four long questions, and the motivation scale alpha coefficient was 0.892. They show that the test items have acceptable to good internal consistency. Cronbach's alpha is a form of internal consistency reliability that spans a set of items, seeks to provide a single measure of success and is often seen as an evidential measure of scale reliability (Tavakol & Dennick, 2011). The alpha value of MCQs is 0.825, and the motivation scale indicates acceptable internal consistency and implies that the items in the test are highly interrelated and, thus, are capturing the high-order thinking skills. By contrast, the alpha value for the long questions, 0.762, was within the acceptable levels of reliability and much more appropriate since internal consistency of .70 – .90 is most suitable for most educational and psychological assessments.

This small difference in reliability can be explained by the difference between MCQs and long questions as kinds of items. Multiple choice questions are more controlled and less likely to have much variation in difficulty level and scoring bias compared with long questions, which are more based on the scorers' perception of what constitutes a good answer. As suggested by Nunnally and Bernstein (1994), alpha values above 0.7 are considered acceptable for research purposes; the higher the alpha value, the better the internal consistency. To improve the quality of long questions, increasing the definition of scoring criteria, training the graders, or even increasing the number of long questions could assist. In totality, the two sections of the test exhibit reasonable reliability that may be used in education, with MCQs having a reliability rating above that of long questions.

Pilot Study

A preliminary investigation, a pilot study, was undertaken prior to commencing the research procedure to maintain internal validity and assess reliability. A pilot study facilitated the researcher in making necessary revisions to the test items if considered necessary. It included 24 male pupils in the fifth grade from a public sector boys' primary school, Gorikote Astore and Ahmedabad. The opinion of the expert was organized. The school was selected by using convenient sampling techniques. In the fifth grade, a total of 24 pupils participated. The pilot research aimed to determine the clarity and lack of confusion in the questions in the mathematics achievement test. After that, item analysis was done, which is described in detail. First, 14 questions were created for the mathematics pretest: 8 MCQs and 6 long questions. After item analysis, items 7, 8, 13, and 14 were removed from the test as they did not fit the criterion established for inclusion, thus making the test valid and reliable.

Item Analysis

The detailed results in Table 4 of item analysis also facilitate the interpretation of test items, and the indices of item difficulty index, discrimination index, and distractor efficiency can be used to systematically evaluate the performance of each item (Rezigalla et al., 2020; Rejeki et al., 2023; Elgadal & Mariod, 2021). Item DIF calculated by the criteria of percentage of correct answers identifies them as easy items (≥78%), acceptably difficult items (25-78%), and highly difficult items (<25%) (Rezigalla et al., 2020; Rejeki et al., 2023; Elgadal & Mariod, 2021). In the present analysis, the levels of difficulty were found to fall between 0.58 and 0.70, thereby categorizing the items as moderately easy. For example, the difficulty values of items identified as Item 1 and Item 4 suggest that the identified questions were relatively easy, as 70% and 67% of students, respectively, got the answers correct. Such levels of difficulty give a general background on the performance and understanding of the students.

Table 4. Item Analysis of Higher Order Thinking Skills Pretest

Item No.	Item Difficulty Level	Item Discrimination	Distractor Analysis			
			A	B	C	D
1	0.70	0.50	2	3	17*	2
2	0.58	0.50	14*	4	4	2
3	0.58	0.25	2	4	14*	4
4	0.67	0.25	16*	2	4	4
5	0.58	0.75	2	14*	6	2
6	0.58	0.50	14*	6	2	2
7	0.20	0.083	7	8	5	4
8	0.83	0.17	2	20*	2	2
9	0.58	0.75				
10	0.58	0.75				
11	0.58	0.75				
12	0.67	0.25				
13	0.20	0.083				
14	0.20	0.083				

Another important indicator is the DIS, which measures the correspondence of each item to high-achieving or low-achieving students with poor (DIS ≤ 0.20), acceptable (DIS 0.21-0.24), good (DIS 0.25-0.34), or excellent (DIS ≥ 0.35) classification (Rezigalla et al., 2020; Rejeki et al., 2023; Elgadal & Mariod, 2021). In this case, the level of discrimination as attained by Items 1, 2, and 6 was 0.50, an indication of their ability to well distinguish student performance levels appropriately. Most notably, Items 5, 9, 10 and 11 have the highest Discrimination Index of 0.75, meaning this item yields good discriminant for high and low-achieving students. At the same time, Items 3, 4, and 12 remain relatively satisfactory in their differentiation with a discrimination index of 0.25.

Distractor efficiency (DE) builds upon this by measuring the attractiveness of such wrong options, thus enriching the evaluation. Cohen (2014) classified those distractors that received a 5% response as functional distractors, while the remaining were non-functional distractors (Rezigalla, 2022; Kumar et al., 2021; Obon & Rey, 2019; Date et al., 2019). Overall, the majority of distractors, as shown in Table 4, whose level of effectiveness can be estimated through selection rates, functioned well except for items 7 and 8.

The detailed results in Table 4 of the item analysis described that Question 7 proved to be moderately difficult, DIF = 0.20 but weakly discriminative, DIS = 0.083, where distractors were almost equally plausible as the correct answer (Rezigalla et al., 2020). It was omitted because it could not properly measure or differentiate between the abilities of students. Elgadal & Mariod, 2021; and Rejeki et al., 2023, consider that Question 8, with the value of DIF = 0.83, had a DIS = 0.17, and this means that this item was too easy, and it cannot distinguish between high and low-achieving groups. Thus, it was excluded to enhance the effectiveness of the given assessment. Besides, Questions 13 and 14 proved again to be moderately difficult, DIF = 0.20 but weakly discriminative, DIS = 0.083 (Rezigalla et al., 2020). It was omitted because it could not properly measure or differentiate between the abilities of students.

The overall analysis supports the statement that the test items have appropriate and valid distractors and show high discriminant validity. Notably, Item 5 attests to the highest discrimination index, suggesting that an item has the potential to discriminate among the students' achievements. Therefore, it can be argued that the overall quality of the test items is high, and the selection of the distractors also makes the test valid in terms of providing reliable results as to the student's performance. Thus, performing such an item analysis improves test equity, adds validity to measures of students' performance, and helps to make improvements to future tests and assessments (Rezigalla et al., 2020; Rejeki et al., 2023; Elgadal & Mariod, 2021; Triono et al., 2020). Besides, after item analysis, items 7, 8, 13, and 14 were omitted because they could not properly measure or differentiate between the abilities of students.

Results

In this study, the independent samples t-test and the Wilcoxon signed-rank test were employed to analyze the difference in the HOTS and motivation in the experimental and the control groups. The independent samples t-test was used to analyze the difference in the pretest and post-test of the experimental and control conditions on HOTS. This test is suitable because it is used to compare the means of two different independent groups with a view to ascertaining if the difference is statistically significant. This testing is done based on the premise that the distribution of the data under study is normal, and this was determined through the normality test on HOTS scores for both groups, supporting the use of the parametric test.

In analyzing motivation, the Wilcoxon signed-rank test was preferred since the motivation scores of the experimental group and the control group before and after treatment do not have a normal distribution. Because of the non-normality of the distribution of the mean motivation scores, the Wilcoxon signed-rank test was used to compare the paired data of the same group. The lack of normal distribution of data used to compare the means of related samples makes this test suitable for use. It offers a useful way to measure the importance of changes in motivation in each group pre and post-intervention without making assumptions of normal distribution, which are necessary for parametric tests.

Normality Test

The findings of the normality test shown in Table 5 described that the posttest scores for all evaluated variables follow a normal distribution. The claim is supported by the significant outcomes obtained for the control group (P=0.098>0.05) and the experimental group (0.088>0.05), both of which are above the significant value of 0.05. More precisely, while assessing the pretest results of the control group, it was found that the lower-order thinking skills shown had a significant value of P= 0.070>0.05. On the other hand, the posttest results of the experimental group showed a significant value of P= 0.095>0.05. The above results are shown in the above table, and all the p-values (0.088, 0.089, 0.70, 0.095) are above the significant value of 0.05, which shows conformity to the criteria for statistical normality. Hence, it is concluded that the normality test findings showed that the data follows a normal distribution and aligns with accepted statistical standards. So, the parametric statistics may be used to analyze the data. The results of the Shapiro-Wilk normality test, shown in Table 3, confirm that the posttest scores for all assessed variables (Before Treatment and After Treatment) and a control group of motivation do not follow a normal distribution. It is assessed by the significant values obtained for the pretest (P=0.000<0.05) and the posttest (P=0.000<0.05), both of which are below the standard level of 0.05. The most interesting aspects of these results are clearly below the 0.05 value, which failed to indicate conformity to the standards for statistical normality. The results of the normality test confirm that the data do not follow a normal distribution. Therefore, to analyze the data on students' motivation before and after treatment, the non-parametric Wilcoxon Signed Rank test was used.

Table 5. Normality Test of Pretest and Posttest of Students in Terms of HOTs and Motivation

HOTs and Motivation	Group	Shapiro-Wilk Test		
		Statistic	df	Sig.
Pre-test of Students in terms of HOTs	Experimental	.723	27	.095
	Control	.785	27	.070
Post-test of Students in terms of HOTs	Experimental	.461	27	.089
	Control	.746	27	.088
Student Motivation Before Motivation	Experimental	.549	27	.000
	Control	.496	27	.000
Student Motivation After Treatment	Experimental	.500	27	.000
	Control	.488	27	.000

Gamification Based Formative Assessment and High Order Thinking Skills

H_1: Students who participate in gamification-based formative assessment in mathematics teaching show greater improvement in higher-order thinking skills (analysis, synthesis and evaluation) compared to those who participate in traditional-based formative assessment.

Table 6 shows that the pretest score in HOTS in the experimental group (M = 1.03, SD = 0.33) was slightly higher than that of the control group (M = 0.92, SD = 1.35). The higher mean in the experimental group was balanced out by the larger standard deviation of pretest scores in the control group. To compare the pretest scores between the two groups, we conducted an independent samples t-test. The t-test results were t (52) = 0.76, p = 0.448 (two-tailed). If the p-value is larger than the conventionally established significance level of 0.05, we fail to reject the null hypothesis. It indicates that there is no significant statistical difference between the pretest scores of the experimental and control groups. More specifically, we were comparing the two groups before the intervention began in terms of their higher-order thinking skills. The magnitude of that difference was also further assessed with Cohen's d, which resulted in a small effect size of 0.20. Cohen (1988) considers an effect size of 0.20 as the size of a difference in the pretest scores between the two groups to be practically insignificant. Finally, the pretest score difference was non-significant. It was within the 95% confidence interval for the mean difference between the groups of -0.36 to 0.81, which includes zero, confirming that the pretest scores were not significantly different in the two groups. Overall, before (pretest) the intervention, the levels of higher-order thinking skills between the experimental and control groups were equivalent. Hence, it is a critical finding, as it ensures that any differences in performance that follow can be attributed to the interventions (gamification-based formative assessment vs traditional formative assessment) rather than prior differences in cognitive abilities.

Table 6. Descriptive Statistics and Independent Samples t-Test for Pretest of Higher-Order Thinking Skills (HOTS)

Group	N	Mean	SD	t	df	Sig. (2-tailed)	Mean Diff	Std. Error Diff	95% CI of Diff		Cohen's d
Exp.	27	1.03	0.33	0.76	52	0.448	0.22	0.29	-0.36	0.81	0.20
Control	27	.92	1.35								

The analysis of HOTS, presented in Table 7, also confirmed that in the posttest, the experimental group scored significantly higher than the control group. The experimental group that received a gamification-based formative assessment had a higher mean score of 7.85 (SD = 1.10) than the control group that received a traditional formative assessment and had a mean score of 2.81 (SD = 1.39). From this difference, it is inferred that the experimental group displayed a higher level of improvement in higher-order thinking skills after the intervention.

Table 7. Descriptive Statistics and Independent Samples t-Test for Posttest of Higher-Order Thinking Skills (HOTS)

Group	N	Mean	SD	t	df	Sig. (2-tailed)	Mean Diff	Std. Error Diff	95% CI of Diff		Cohen's d
Exp.	27	7.85	1.10	14.78	52	0.000	5.04	0.34	4.35	5.72	4.03
Control	27	2.81	1.39								

In this case, an independent samples t-test was computed to compare the mean scores of the two groups, and the observed difference was statistically significant. The t-value is 14.78, df = 52 and p = 0.000 ($p < 0.001$). This p-value suggests that there is a significant difference in the means, suggesting that the use of the formative assessment tool using gamification was highly effective in enhancing HOTS compared to the traditional assessment approach.

However, to quantify this, Cohen's d was computed to establish the extent of this difference. The calculated value of effect size was 4.03, which is beyond Cohen's (1988) criteria for a large effect size. Such a high value of the effect size means that the interventional tool, that is, gamification-based formative assessment, had a highly positive impact on the students' cognition abilities, overcoming the results of the traditional formative assessment. The 95% confidence interval ranged from 4.35 to 5.72, demonstrating the precise and accurate effect and that the difference is not contrived because it is neither explained by random sampling errors nor limited to a specific sample.

Hence, the presented results support the hypothesis that formative assessment in the sense of gamification has a positive impact on the development of higher-order thinking skills for analysis, synthesis, and evaluation. The results are consistent with the hypothesis that students who engage in formative assessment gamification improve their cognitive skills more than students who do not. The overall effect size and the statistically significant findings reinforced the use of gamification to enhance higher-order thinking in mathematics education.

Gamification Based Formative Assessment on Students Motivation

H2: Students who participate in gamification-based formative assessment in mathematics teaching show higher motivation, both intrinsic and extrinsic, compared to those who participate in traditional-based formative assessment.

Table 8 indicates that the Wilcoxon signed-rank test was performed to examine the impact of the gamification-based formative assessment on the motivational levels of the students of the experimental group before and after treatment. This study further provides clear details that motivation was significantly higher after the intervention. The motivation score among the experimental group prior to the intervention was computed as mean = 12.85, SD = 2.23. After the intervention, the motivation scores increased to 27.41 (SD = 4.47) in the mean sense. Applying the Wilcoxon signed-rank test obtained a Z-value of 4.472 at a p-value of 0.000 ($p< 0.001$) to suggest a significant change in motivation before and after the intervention. The Spearman Rank Order correlation coefficient (rho) was calculated at 0.86, which, according to Cohen (1988), indicated a large effect size. From this, it can be deduced that the formative assessment using gamification-based formative assessment significantly boosted the level of student motivation. A rho of 0.86 means that before and after motivation scores are highly correlated, which, in effect, defines motivation as having improved after the intervention.

Table 8. Descriptive Statistics and Wilcoxon Signed Rank Test Results for Student Motivation Before and After Treatment (Experimental Group)

Treatment	N	Mean	Standard Deviation	Z	p-value	Effect Size(r)
Before Intervention	27	12.8519	2.23097	4.472	.000	0.86
After Intervention	27	27.4074	4.46576			

In light of the large effect, indeed the statistically significant score obtained, it can be attested that with the use of formative assessment – gamification, student motivation was effectively boosted. The findings give credence to the argument that actual formative assessment gamification-based participants are more motivated than traditional-based actual formative assessment participants. Hence, this goes a long way in showing how useful it is to incorporate gamification into teaching and learning resources in mathematics education.

The Wilcoxon signed-rank test was used to analyze the difference in students' motivation in the control group as an effect of conventional-based formative assessment during the teaching intervention, as shown in Table 9. A statistical significance was established on motivation post-intervention in the study.

Table 9. Descriptive Statistics and Wilcoxon Signed Rank Test Results for Student Motivation of Control Group

Treatment	N	Mean	Standard Deviation	Z	p-value	Effect Size(r)
Pretest	27	10.2222	.42366	-2.357	.018	0.32
Posttest	27	10.6154	.49614			

The control group's pre-intervention mean motivation score was 10.22 (SD = 0.42). Subsequent to the intervention, the mean motivation score reached 10.62 with SD = 0.50. The Wilcoxon signed-rank test for the study revealed a Z-value of -2.357 and a p-value of 0.018 (.018 < 0.05); therefore, it was concluded that there was a statistically significant difference in motivation before and after the intervention had been conducted on the students.

The magnitude of the relationship was considered moderate, rho = 0.32 (Cohen, 1988). This implies that the formative assessment, based on tradition, had a moderate positive correlation with the motivation level of learners. A rho of 0.32 shows that the correlation coefficient between the pretest and post-test motivation scores values was moderate. Hence, the use of the intervention increased participants' motivation slightly, although not as significantly as the results obtained using the gamification-based intervention.

Therefore, based on the small to medium effect size and statistical significance, it was possible to establish that traditional-based formative assessment positively impacted the student's motivation in the control group. The results support the hypothesis that participation in formative assessments can increase motivation. Still, the size of the response seems to be lesser when compared with the effect found when gamification was used, which is seen from the size of the effect. Therefore, this implies that the strategies used in gamification-based formative assessment compared to the traditional-based method shall have a greater influence on the motivation of the student.

Discussion

Based on the outcomes of this research, there is convincing evidence that gamification-based formative assessment improves students' higher-order thinking abilities (HOTS) and enthusiasm for learning mathematics-related topics. In light of previous research, the findings are addressed in the following sections.

Higher-Order Thinking Skills (HOTS)

This current study provides strong empirical support that gamification use of formative assessments improves the higher-order thinking skills of analysis, synthesis, and evaluation. In regard to the experiments' results, the improvements regarding cognitive skills in the experimental group that did complete the game-based learning environment were significantly higher than in the traditional control group using formative assessments. This gives the strength of this interventional method where the effect size (Cohen's d = 4.03) strengthens the present results with other scholars, such as Ghoulam and Bouikhalene (2024) and Aibar-Almazán et al. (2024), who also observed enhanced cognitive engagement regarding the gamification.

Due to the element of game mechanics like incentives for performance, designing of activities as quests, and instant assessment, students' mental involvement was heightened. The presence of this feature helped enhance greater cognitive efforts among the students due to increased interactivity with the material presented on the platform. These findings align with prior works of Kollo et al. (2024) in which similar positive impacts on critical thinking via Kahoot were reported in similar learning environments, which provides further support to the use of gamification in different faculties. The related studies explained by Jauhari et al. (2024) also contribute to and endorse the findings of the present work, in which the KBT model that adopts Kahoot refined Teams Games Tournament positively promotes HOTS in mathematics instruction. This is in congruence with this current study's interest in the game mechanics that foster analytical, synthesis and evaluation skills.

Further, education based on Kahoot involves the use of games in education, which offers an educative setting with constructive immediate feedback that enhances higher-order thinking skills as well as a positive learning attitude. Student involvement is experienced through the instant feedback and scores on the board; it fosters a positive learning atmosphere in which a student can employ their skills without coercion from other forms of evaluation. More DeKelerk and Kato (2017) argue that optimal knowledge acquisition is hampered by test anxiety and traditional forms of evaluation. This finding is aligned with the ideas explained by Sinnivasagam and Hua (2023), who said that there are massive advantages of Kahoot implementation in the class, which include motivation, enhanced interactions in the class, and high energy in the educational sessions.

When comparing the results found by Irawan and Latifah (2023) to those of other studies, the authors specify that both of the investigated variables have considerable evidence that concerns the consequences of integrating the Kahoot application into learning practices. Its particular benefits relate to context; teachers can apply it as a means to assess their pupils in terms of problem-solving and to make the process more enjoyable and thought-provoking. The research also enhances the Kahoot literature that asserts that Kahoot also fosters a good learning environment that encourages creativity and results in higher student satisfaction regarding learning outcomes. This optimistic view on Kahoot-based gamification may prompt educators and policymakers to scale up the use of Kahoot in classrooms and other educational settings because of the potential for making learning better.

Moreover, accenting cultural-social components in online learning environments refers to the enhanced quality of education, as argued by Singh et al., 2020. The application of gamification in the classroom can improve students' analytical, problem-solving, and creative skills in equal measure. Mee et al. (2020) observed the same reasoning. According to the authors, students are equally motivated to learn a language when interesting activities like gamification are involved. Umboh et al. (2021) also concluded that Kahoot improved the achievement of integer count operation and encouraged group work at the same time, which also increased student participation while encouraging instructors to be innovative in developing technology-integrated lessons.

However, other research suggests that Kahoot-based gamification has net positive effects; however, the opinion of the literature regarding its impact on HOTS is quite divided. According to some studies, learners achieve impressive gains in comprehending and command skills; in contrast, extrapolative abilities benefit less from the application. For example, using Kahoot, Truong & Dinh (2024) argue that although the students are interested and active in the game, the structure of the game needs to force them to think analytically and critically. Similarly, Yu (2021) noted positive attitudes towards 'Kahoot-integrated learning' but no enhanced test performance among Singaporean university students; therefore, he emphasized the variability of the Kahoot application.

Some of the studies in this area compared contrasting interventions but needed an appropriate research design. Even though this study had a well-developed procedure using pre-and post-tests of a real experimental design, other apparently strong studies like studies of Yu (2021) and Truong & Dinh (2024) might have had certain methodological drawbacks, for instance, no control group can enhance the credibility of conclusions. Also, these studies might have controlled for only a few aspects of external variables, such as the duration of the tool or the level of interaction with the gamification tool.

Another limitation reported in the body of knowledge is related to the period of the gamification interventions. Other researchers, Aibar-Almazán et al. (2024) and Kollo et al. (2024) pointed out that the length of the activities that include gamification also has an impact on the learners. On the other hand, some works present moderate effects on academic achievements, for instance, the study of Yu (2021); the reason may be the short duration of the gamification interventions or learners not having enough time to gain from the gamification. Additionally, problems concerning the availability of Internet connections and technical contexts are often disregarded in research in the field of gamification. In some cases, especially those practices underlined in the study by Tandiono (2024), for example, students' limited access to stable internet connections or issues related to the functioning of platforms, such as Kahoot, the implementation of gamified approaches to assessment will be questionable. These may help explain why interventions using Kahoot have yielded varying outcomes in properly testing learner engagement and learning abilities. Further, based on Tandiono (2024), Kahoot can support the depth of the students' learning only if it is combined with other technological tools and methodologies. Hence, this implies that Kahoot, though it can make students participate and promote engagement, does not necessarily promote higher-level learning and cognitive functioning without other supports and incentives provided together with the Kahoot games.

Based on these conflicting views and limitations, the research outcomes of the current study point to the fact that gamification-based formative assessments, if properly utilized, can improve HOTS and overall cognitive activities. Therefore, further research is needed to ascertain how best to adopt these tools and how best to interphase them with other intellectual teaching approaches since it is broadly evident that these tools promote high-order thinking.

Motivation

Gamification-Based Formative Assessment (GBFA) with Kahoot

The findings of this study overwhelmingly affirm the hypothesis that GBFAs are advantageous to intrinsically and extrinsically motivated primary school students in mathematics as compared to traditional-based formative assessment. When analyzing the changes in the motivation levels of the members of the experimental group after the implementation of the proposed gamification-based intervention, the results demonstrated a clear and significant improvement. The mean motivation score of the participants before the intervention was 12.85 (SD = 2.23), while that after the intervention was 27.41 (SD = 4.47). Wilcoxon signed-rank test supported this improvement by showing a $Z = 4.472$, $p < 0.001$, thus, considered highly significant. Also, the magnitude of the relationship as measured by rho was large, rho = 0.86, which indicated that the influence of gamified assessment on students' motivation was significant and had a large effect. In gamification, aspects like tasks and feedback aspects, which are innate challenges, bear inherent interest and enjoyment that touch the intrinsic learning of the students, thus increasing their motivation to learn. At the same time, the stimulating use of incentives, points and competition stirs up the students' extrinsic motivation levels. Kahoot Quizzing and any form of gamification integrated and used as formative assessment is an effective reformative model for enhancing student engagement. Included are challenges, rewards, leaderboards, and feedback manners, which all meet the extrinsically motivational elements as well as the intrinsically motivating elements. The related research evidence supports that more engagement, motivation, and performances turned out higher than traditional-based formative assessment (Jarrah et al., 2024; Aliyu et al., 2022).

Through an interactive and competitive environment, Kahoot motivates learners themselves by sparking curiosity and enthusiasm (Aliyu et al., 2022). There are different advantages offered by the platform that contribute to the increase in the degree of attention, namely in achieving greater concentration. At the same time, the students receive quizzes as a form of the game (Setiawan & Soeharto, 2020). Points, badges, and rank are also considered extrinsic motivations that are driven by the achievement-oriented goals of students. These two motivational factors then amplify the amount of interest and enhance learning capability very significantly. The current research has revealed that GBFA plays a critical role in increasing both the interest and involvement of learners in academics compared to traditional-based formative assessment. For example, Cárdenas-Rogel et al., 2023 have revealed that the participation levels enhanced within the natural science classes with the help of the Kahoot application; at the same time, Jarrah et al., 2024 provided detailed information on a similar rise in participation within mathematics classes. Furthermore, Kahoot has been shown to impact class relations and student engagement, making it a useful tool in promoting the engagement of groups and active learning (Khairisya & Daulay, 2022).

Traditional-Based Formative Assessment (TBFA)

On the contrary, in the traditional formative assessment group, only a modest enhancement of motivation was observed. The pretest mean motivation score was 10.22 (SD = 0.42) and increased to a slightly higher posttest mean of 10.62 (SD = 0.50). A Z-value of -2.357 and p = 0.018 was computed for the Wilcoxon signed rank test, indicating statistical significance. However, the effect size (rho = 0.32) was moderate, indicating a smaller impact than the experimental group. The traditional method helped boost motivation to some degree. However, the benefit was not as great as that of the gamified elements of the second method that actively involved students. Traditionally, extrinsic motivational factors, e.g., grades and teacher feedback, are the primary focus of assessment, with almost no concern for intrinsic motivation. For a long time, traditional formative assessment (TFA) has been used to assess and monitor student learning, including teacher-led quizzes, paper-based tests etc. The feedback that these methods provide, by and large, revolves around the idea of improving performance and has a high extrinsic motivation factor, mainly based on grades and teacher recommendations. Research indicates that TFA contributes to the improvement of motivation through teaching with structured feedback and scaffolding strategies (Sunra & Samtidar, 2023; Pangarso & Istiyono, 2022). One of the first advantages that TFA can provide is immediate feedback to close learning gaps and enhance understanding of the material (Pangarso & Istiyono, 2022).

Furthermore, it has been established that integrating self-assessment with teacher-led TFA results in an increase in both language competence and motivation (Dmitrenko et al., 2021). There are certain advantages to TFA, but there are also some disadvantages, such as the problem of encouraging intrinsic motivation. There is some evidence that extrinsic motivators, such as praise from teachers or grades, may result in moderate gains in motivation. However, these methods seldom result in pupils being fully dedicated to the subject matter, and they rarely can maintain high levels of interest over extended periods. For instance, TFA will often cater to the requirements of relatedness and competence, but it will not do so for intrinsic motivators like fun and curiosity (Pat-El et al., 2023). When it comes to the internal environment, conventional techniques contribute to the required feedback mechanisms; nevertheless, their effect on intrinsic motivation is often less significant.

The comparison between TBFA and GBFA underscores the superior impact of gamified approaches. While traditional methods are effective in providing feedback and addressing extrinsic motivators, their impact on intrinsic motivation remains limited. In contrast, Kahoot effectively combines intrinsic and extrinsic motivators, creating a more engaging and comprehensive learning experience. For example, GBFA with Kahoot yielded a 44.55% improvement in learning motivation among elementary students, compared to modest increases observed in traditional assessments (Setiawan & Soeharto, 2020). However, GBFA has challenges. Limitations such as time constraints during quizzes, reliance on stable internet access, and occasional technical issues can hinder its effectiveness (Resmayani &Putri, 2022). Despite these drawbacks, the overall benefits of GBFA, particularly in fostering intrinsic motivation and improving classroom engagement, make it a compelling alternative to traditional formative assessment practices.

This comparison between the traditional assessment and the gamified assessments demonstrates the improved assistance that GBFAs give for both internal and extrinsic motivation. The experimental group not only showed a greater level of motivation in general, but they also assessed a much larger effect size, which indicates a higher level of change that is highly significant. With regular use, this shows how gamification can provide a more comprehensive engagement with students across their diverse motivational needs than traditional methods. Implications for educational practice are particularly important with regard to mathematics education. Gamification includes the use of components of play, challenges, play and real-time feedback to create the resilience of personal satisfaction and the excitement of learning in an academic setting, which permits an increased intrinsic motivation. Rewards such as badges, leaderboards, point systems etc., also act as extrinsic motivation to motivate and make learning outcomes more tangible and interesting. What this means, again, is that the intrinsic and extrinsic motivational factors are balanced and integrated so that it is not only good but also becomes a sustainable approach to student engagement in mathematics that both competes with other endeavors and enhances performance in mathematics.

Overall, the study demonstrates that gamification of formative assessment makes a huge motivational difference in the improvement of both intrinsic and extrinsic motivation in primary school students for mathematics, far outperforming the motivational effects of traditional formative assessments. Finally, these findings support the use of gamification as part of a central practice in modern educational practices, especially in mathematics, where the goal is to foster motivation, and that, in turn, helps develop higher-order thinking skills and ultimately leads to long-term academic success.

Conclusion and Recommendations

The research indicates that formative assessments utilizing gamification positively influence higher-order thinking skills and motivation among primary school pupils enrolling in mathematics classes at Boys High School Gorikote Astore. Higher-order thinking skills were significantly improved in the experimental group as compared to the control group. However, this was seen in comparison to the control group. It was shown by the significant improvements that were seen in the results collected after the post-test (p =.000, Cohen's d = 4.03). As a consequence of this, the data provide support for the hypothesis (H1), and it demonstrates that gamification is effective in improving higher-order thinking skills. After the session, the Wilcoxon Signed Rank test showed that the experimental group saw a substantial increase in their levels of motivation ($Z = -2.34$, $p = 0.019$, $r = 0.86$). This improvement was the result of the session. The control group, on the other hand, had an improvement that was statistically insignificant but may be considered marginally significant. The result presents evidence of the hypotheses showing the positive effect the gamified formative evaluation exerts on student motivation. Quick corrective feedback, a competitive learning environment, clear challenges with structured time intervals for scoring and leaderboards are combined into gamified formative assessments. Hence, this eliminates pressure and anxiety due to immediate corrective individual feedback, which helps students relax and think more openly, using their cognitive skills for creative and critical thinking.

On the other hand, conventional formative assessments are hindered by time constraints and large classroom sizes, which prevent teachers from delivering timely, constructive feedback to all students. Failure to respond correctly to direct questions frequently triggers anxiety, particularly in peer-influenced settings. This anxiety, in turn, impairs cognitive performance and stifles creativity. This stress inhibits students' potential for innovation. The research findings indicate that gamification, especially through tools like Kahoot, has the potential to revolutionize educational outcomes by promoting greater student engagement and active participation in the learning process. The findings of the study suggest that incorporating gamification-based formative assessment methods into elementary mathematics instruction is essential for delivering timely feedback and monitoring performance effectively. These approaches offer a strategy to enhance higher-order thinking skills and motivation while simultaneously tackling the ethical issues associated with traditional evaluation methods. The research findings could allow teachers to continue to assess the performance of students, evaluating the educational methods used by teachers. Another research study can also be conducted using a mixed method design to explore further the effect of a long intervention period on gamification-based formative assessment in terms of higher-order thinking skills and motivation. Gamification-based formative assessments serve as an efficient way to empower educational institutions to boost teaching and learning by engaging and achieving higher learning outcomes. The application of these methods is effective at timely feedback and offers the opportunity to assess instructional success. In addition, they support student motivation and substantially enhance mathematics performance in higher-order thinking skills such as analysis, evaluation and synthesis, especially at higher levels.

In other words, providing a simulative teaching environment in which to teach mathematics can improve students' performance in high-order thinking skills associated with teaching mathematics. Prompt constructive feedback plays a very important role in effective teaching while delivering content in the classroom. In contrast, in conventional-based formative assessment practices, it is difficult to provide prompt corrective feedback to all students when their strength is large numbers within a limited period. Prompt constructive feedback is possible through gamification-based formative assessment practices that students can easily understand. In literature, it has been found that students feel test anxiety and stress when they are unable to provide the right response to their colleagues. However, gamification offers positive corrective feedback and competition space, and by having ranks, leaderboards, and scores, students' performance is shown. It thus would be a positive force in encouraging students to teach the subject of mathematics. It is, therefore, going to be used in the classroom to learn. So, gamification-based formative assessment practices should be employed to create a simulative learning environment at school.

- Primary school teachers should integrate gamification-based formative assessments, like Kahoot, into their mathematics curriculum to enhance higher-order thinking skills among students.
- Gamification-based assessment practices may be used in schools to stimulate students' motivation and get their attention during instruction in mathematics content.
- Evaluating students' knowledge of lesson efficacy requires constant monitoring and feedback strategies. The continuous improvement approach helps teachers provide quick feedback and upgrades by using gamification-based formative assessment. This approach enables teachers to provide prompt feedback and evaluate the instruction given to students during sessions, thus strengthening their connection to their pupils' needs and preferences. It should be incorporated while delivering content to achieve more desirable results. Hence, it is recommended that GFA be used to provide immediate constructive feedback during lecture delivery in the classroom.
- It is essential to ensure reliable access to the Internet and adequate technical resources in schools. This assistance will be important for efficiently implementing tests based on gamification. It can include offline gamified activities to overcome certain limitations, such as time restrictions and the demand for

reliable internet access.

- Kahoot-based gamification may create a cooperative and enjoyable learning environment in mathematical courses taught at the primary level. This will enable students to develop their problem-solving and critical-thinking abilities. Because it offers pupils a fantastic learning environment and does not subject them to stress or worry, when students feel easy, they are able to make excellent use of their cognitive abilities. In contrast, when students have anxiety and stress, their cognitive abilities are declined. Hence, it is recommended that this emerging technique be incorporated to provide learning more effectively.
- Future scholars should investigate the enduring effects of gamification-based formative assessments on learning outcomes, focusing on high-order thinking skills and motivation in primary and secondary grades. Additionally, it is necessary to investigate the effectiveness of diverse gamification technologies in different educational contexts by focusing on primary students' general high-order thinking skills.
- Apart from this, with a larger population and more diverse studies, it is crucial to generalize findings across different regions and student populations. However, after the implementation of gamification-based formative assessment of prospective teachers, further work may be expected to examine the role of teacher attitudes and competencies in successfully implementing gamification in the classroom.
- Teachers and practitioners in the field of education should be enlightened on how to use the concept of gamification in assessment processes. Education on the proper usage of the tools and how they achieve specific objectives can prevent instructors from using the tool in a way that will reduce the effectiveness of the game. Hence, training relating to the usage of gamified formative assessment may be arranged to improve teachers' skills.

Limitations of the Study

Research Design: While the study adopted a true experimental design, this was only a quantitative approach. Using both quantitative and qualitative data would provide a broader spectrum of gamification's influence on students, revealing not only the performance indicators but also describing the exact experience, difficulties, and incentives in more detail.

Duration of the Experiment: Since the study was conducted over 8 weeks of treatment, it may be limited in assessing changes in higher-order thinking skills and motivation resulting from the use of gamification-based formative assessments for learning. It might have been more beneficial to have a longer intervention period, closer to 15 weeks or more, to understand further lasting impacts on the students' learning and motivation.

Lack of Longitudinal Data: One important limitation of this study is that it does not measure the long-term impact of GFA on higher-level thinking abilities and motivation. Such research could present important information on how these impacts change as students grow and whether the positive effects are maintained as students move to the next grade level.

Sample Size and Generalizability: A major weakness of the study was that the subject population was drawn from only one district; the sample size was 54 students, which may undermine the validity of the results. It is important to carry out a similar study with a larger and heterogeneous sample in another district or other parts of the country to increase the generalizability of findings.

Contextual Limitations: All research subjects were selected from government schools within a particular region, and thus, the study findings may not reflect the experiences of students in private or urban schools or even from different regions. More studies in other settings of education would ensure the actualization of such effects of gamification-based formative assessments in different learners.

Statements and Declarations

Ethical Considerations: This researcher also ensured absolute compliance with ethical standards as well as general prescribes appropriate for research involving children. The following measures were implemented to uphold the ethical standards of the study. The researcher used several approaches to ensure that the study was conducted in accordance with the highest possible ethical standards for research with children and adolescents. These steps were included in the implementation process to address ethical concerns.

Permission and Parental Informed Consent: During the experimental period, the researcher obtained formal permission from the school principal to use the IT lab. Consent information was provided to the parents or the guardians of the entire participant regarding the study description, aims, methods, potential risks, expected advantages, and participants' rights. Parental informed consent was sought in writing so that the parents or guardians could comprehend the study, and the child's participation was voluntary. Parents were also provided with an assurance that they could pull their child out of the study at any one time without any consequences.

Confidentiality and Anonymity: The participant data was treated with great confidentiality. Participants' identities were masked in pre- and post-test responses to ensure the subjectivity of the data collected. Each student was given a roll number to maintain anonymity during analysis and report writing. Hence, to maintain the policy of confidentiality, students were advised not to write their names on tests.

Data Protection: Any scores and other related data obtained throughout this study were maintained in strict confidence and used exclusively by the researcher. These measures ensured that participants' identities and data procured from each participant were well protected against likely attempts by unauthorized individuals.

Neutrality and Ethical Integrity: The researcher was neutral throughout the process to ensure that the study was not biased. First, participants were treated equally by being asked an equal number of questions; second, risks to participants were kept to a minimum when conducting the study on students.

Ethics Approval and Consent to Participate: The researcher sought and obtained consent from the participants in this study: fifth-grade students, the School's Principle and their parents. Reasons and justifications for this process include the promotion of ethical values of transparency and abidance with special ethical considerations to create a supportive context for participants and to correspond to the goals of the study.

Conflict of Interests: The author states that there is no conflict of interest of the author in connection with this study. It should be noted that all conclusions presented in the work are based exclusively on the data obtained and analyzed during the research process.

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