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Abstract

Using gamification in assessments makes learning more engaging and encourages students to participate actively in the classroom. This study investigates the effect of gamification-based formative assessment on academic achievement among primary school students in the context of mathematics learning. Randomized pretest-posttest control group design was utilized in a true experimental design. The target population of this study contained 10 schools, with 248 students in the 5th class in District Astore, which had internet access and an IT lab. A simple random sampling technique was applied to select the sample as a school from the target population. A pretest and posttest were conducted to gather data on mathematics achievement of cognitive skills. The study used Kahoot in gamification-based formative assessments to determine an improvement in post-intervention academic achievement in mathematics among primary students. It was found that the experimental group had a significantly higher mean score (M = 25.52, SD = 1.74) compared with the control group (M = 14.59, SD = 2.17) with a large effect size (Cohen's d = 4.92), using gamified assessment improves cognition. It implies the extent to which gamification has a positive influence on students' interaction, learning, and success in mathematics. To improve mathematics learning, educators in schools should incorporate games, such as Kahoot, because they are fun, reduce pressure, and increase success. Future studies may be conducted on whether gamification-based formative assessment practices effectively improve the higher-order cognitive skills of students toward mathematics teaching.

Introduction

Technology has brought changes to our education system, particularly in the learning process. One of the most prominent technological approaches is gamification, which is commonly practiced in teaching in the current era. The incorporation of gamification in teaching can be a practical and powerful approach for teachers to develop students' creative learning skills and captivating competition (Zainuddin, Shujahat, Haruna, & Chu, 2020). It is an educational approach that fosters learners' motivation, engagement, participation and interactivity in lessons and stimulates learners to the extent that their learning and knowledge become enlarged (Göksün & Gürsoy, 2019). Different gamification-based formative assessment tools, such as Kahoot, Socratics, and Quizzes, are employed

in teaching-learning processes to make effective teaching in the classroom. These technologies can provide innovative learning opportunities to students in the classroom. They also provide positive interactions between teachers and students, which consequently boost students' learning and motivation (Chaiyo & Nokham, 2017). Kahoot is a platform that is available for free and provides gamified quizzes that give quick feedback. Because of this, it is a good tool for encouraging active learning and higher-order thinking abilities in a variety of areas, including STEM (Wang & Tahir, 2021). Kahoot-based gamification is available and easy to use for both students and teachers.

Over the past few years, gamification-based learning platforms like Kahoot have enjoyed growing popularity with the promise of revolutionizing the way schools operate, in particular with regard to how content can engage and motivate primary school students. Competition, instantaneous feedback, and interactive visuals, as learned by Kahoot, have been proven to improve knowledge retention and experience in learning among different groups of age (Wang & Tahir, 2020; Pellas, 2024). Such a platform offers chances for active learning, which is critical in the educational setting, where the learning objectives are related to the foundation of concepts, with a demand for constant reiteration, especially in the case of mathematics and other similar subjects (Al Rashdi & Gado, 2022). Kahoot integrates game mechanics into learning so that routine assessments become motivating experiences, thus enhancing the fun and making learning effective.

The research demonstrates that Kahoot helps in mathematics education and provides evidence of its efficacy; the game-based structure of the platform enables the efficient delivery of academic performance. Al Rashdi and Gado (2022) reported that the application of Kahoot for the mathematics assessment of primary students resulted in high improvement in students' achievement as well as instructional satisfaction on the measurement of the interactive nature of Kahoot that helped bring math concepts deeper than the traditional ways.

The cognitive, affective side of us is also affected by Kahoot, not just our performance. An office of studies working on the platform's competitive features has reported that the platform enhances the motivation and focus of students. A literature review describes how Kahoot' can improve student performance in the classroom and academically. Students find the activities Kahoot hosted activities frequently more enjoyable, and frequently, teachers report students in the latter instance who usually will not participate in paying attention and engaging. Kahoot gamified the process by not only reducing test anxiety but also by being an active, experiential method of learning through visually engaging quizzes that allow the information to stick memorably (Diaz & Estoque-Loñez, 2024 ; Wang & Tahir, 2020). Let us look at mathematics, which is mainly a case when it comes to engaging the students so that they can develop critical thinking and problem-solving skills. It can be said that the tool Kahoot can serve as a good facilitator of effective learning even when cognitive engagement and emotional investment are used.

In addition to cognitive improvements, Kahoot has positive effects on classroom dynamics. Kahoot-based activities also work where it enhances peer interaction and supplies a safer and more inclusive classroom environment as students feel confident being part of the same class and can ask any question (Wang & Tahir, 2020). In particular, it is beneficial when students are in primary education, where developing a warm and diverse

learning atmosphere can result in permanent positive influences on how students obtain their knowledge and get along (Pellas, 2024). One of the findings of studies is that a school that has a less optimal environment for stimulating learning has less academic achievement and poor retention rates among students (Hattie, 2024). Thus, this study analyzes further the role played by Kahoot as an assessment tool for improving primary students' academic achievement in mathematics and, therefore, offers a starting point for optimizing game-based learning in primary education.

Analyzing both the challenges and solutions to low student engagement and motivation in primary mathematics education, the integration of Kahoot as a game-based assessment tool provides an innovative means of delivering formative assessment addressing low student engagement and motivation. The traditional assessment methods may be lacking the interactive and motivational parts that are important to motivate young learners. However, platforms like Kahoot can fill this gap by providing instant feedback, promoting competition and driving the interactive classroom environment (Wang & Tahir, 2020; Pellas, 2024). With promising results in studies related to Kahoot, this research aims to validate the impact of Kahoot on primary mathematics achievement to add further insight into learning game-based in core subjects such as those that require high student engagement.

Despite extensive research studies that have been done on game-based learning, there is still a notable lack of studies on the longer-term impact of Kahoot on the academic performance of primary students in mathematics. In most studies, the focus has still been on short-term outcomes, meaning an immediate increase in engagement or enjoyment, and only rarely has provided analysis of the long-lasting benefits for academics (Al Rashdi & Gado, 2022; Rayan & Watted, 2024). Another thing to note is that few studies concentrate on how Kahoot affects different mathematical skills, and they encompass higher-order cognitive skills like critical thinking and problem-solving. The study aims to fill these gaps as it investigates how Kahoot's extended effects in mathematics affect academic performance over time, providing inputs for additional studies on how game-based assessment has been implemented in primary education. Kahoot, therefore, is a powerful tool to increase educational outcomes in primary mathematics education. Kahoot uses game mechanics to spark involvement, improve interaction, and excite about and foster meaningful learning experiences in line with modern educational psychology of employing procedures that will make students attend to their work and look towards attaining better grades. This present study attempts to explore these dynamics further and make a contribution to the growing literature on the effectiveness of game-based learning tools for enhancing the academic performance of young learners.

Formative assessment practices are employed in teaching and learning mathematics of primary through paper and pencil format; this type of assessment is stressful and adds pressure to children, hence reducing their interest in mathematics learning (Putwain & Best, 2011; Von der Embse et al., 2018). Studies show that such high-stakes tests may lead to academic pressure, which lowers the desire and feelings and has a detrimental effect on learning achievements (Segool et al., 2013). Instead, tools such as Kahoot are more engaging and might help decrease test-related stress and increase general learning outcomes (Licorish et al., 2018). However, related research studies have been done to assess the effect of Kahoot on primary students' mathematics performance within a rigorous experimental framework. The present research aims to fill this gap by investigating Kahoot as a game-based assessment tool with the general research question of identifying the material's possible contribution to the

improvement of mathematical achievement in primary education through true experimental research with pretest and posttest design.

Objective

The objective of this study is to compare the effect of Kahoot-based formative assessment on primary students' academic achievement in mathematics to traditional formative assessment methods.

Research Questions

What are the effects of using Kahoot as a gamification-based formative assessment tool on the academic achievement of primary students in mathematics in comparison to traditional formative assessment?

Hypothesis

H1: Formative assessments based on Kahoot will significantly increase the academic achievement of primary students in mathematics compared to those who participate in traditional formative assessments.

Literature Review

Theoretical Background of the Study

Gamification in education uses game-like elements to motivate and engage students following their diverse needs. Self-Determination Theory (SDT) explains how gamification meets fundamental human needs, all of which lead to an increase in intrinsic motivation (Ryan & Deci, 2000). The choices in gamified learning to select tasks or levels provide students with a feeling of autonomy. Moreover, with increasing amounts of feedback like points and badges, students are continually reinforced to grow more and more competent with the more and more challenging tasks they encounter. It is all about building confidence and a sense of accomplishment. Elements of collaboration, such as leaderboards and team challenges, create relatedness by creating a feeling of connection with peers. Together, these components enhance intrinsic motivation and help improve student engagement and active participation in the learning experience (Ryan & Deci, 2000). Self-directed learning and persistence are critical factors in game-based learning systems and occur with intrinsic motivation (Deci & Ryan, 2008). Csikszentmihalyi (1990) developed an approach, Flow theory, which provides an immersive state of engagement for learning that is very similar to everyday learning experiences. Tasks are matched to an individual's skill level. In gamification, this theory is instrumental because it provides a model that can be used to create balance in the experience of playing, engaging, and focused on play (Csikszentmihalyi, 1990). While it is difficult to quantify how applicable Flow Theory's principles are in designing learning experiences that will minimize boredom and maximize engagement (Finneran & Zhang, 2005), they are of value.

Cognitive Load Theory is based on managing cognitive resources in order not to overload them (Kalyuga, 2011). This is CLT, structuring tasks so they remove extraneous load and allow students to focus on important content.

The way these tools, such as Kahoot, can achieve this is through the importance of prioritizing critical content and facilitating learning through real-time feedback with simplified feedback (Van Merrinboer & Sweller, 2010). However, this balance is critical to keep in gamified assessments (Kalyuga, 2011). In gamification, mastery and performance goals motivate as well. Senko, Hulleman, and Harackiewicz (2011) wanted to see gamified platforms help with both types of goals, provided that they are done in a supportive and competitive way, so to speak (Senko et al., 2011). According to Hrynchak and Batty (2012), the collaborative elements in gamification provide for deeper engagement by promoting an interactive, problem-solving activity during team activities. There has been immense potential in gamification systems available on digital platforms such as Kahoot to significantly improve academic performance and engagement. Real-time feedback helps teach the tools, provides a medium for monitoring progress and gives the tools such as points and a leaderboard to keep the learner engaged (Zeybek & Saygı, 2024). The Kahoot is used as a building block for building an engaging and supportive learning environment where the learners learn and achieve both academically and collaboratively in subjects such as mathematics and language.

Traditional Based Assessment and Its Impacts

Formative and summative assessments are crucial in education as they help teachers understand the knowledge of the students and help shape the instruction practices. However, traditional assessment, as used particularly in primary mathematics education, does not elicit the intended negative outcome. According to the existing literature, formats of tests also raise pressure and concern among primary students and may even negatively affect their achievements (Cassady & Johnson, 2002; Segool et al., 2013). To young learners, mathematics comes as stressful since they are susceptible to the score they will be given due to the nature of the abstract lessons. Segool et al. (2013) stated that high-stakes testing has adverse effects on students' positive feelings toward the test and can worsen anxiety, hence negatively affecting their performance as well as their motivation in mathematics. According to Putwain and Best, (2011) test-related anxiety causes test-anxiety-related avoidance, where students tend to have a negative perception of mathematics. These results highlight the importance of identifying additional and less stressful means of making assessments valid and academically challenging. Proposals for assessing primary students have highlighted the use of games since they reduce pressure on students in a way that is not linked with traditional testing and assessment (Cassady & Johnson, 2002; Putwain & Best, 2011).

Gamification based Learning and Uses of Kahoot as a Formative Assessment Tool

Gamification-based learning (GBL) incorporates features of games into tests and other types of assessments while having a positive effect on students' attitudes toward testing and test performance. One of the GBL tools exhibiting this characteristic is Kahoot, showing how timed quizzes, computational features, and instant feedback all add value to a lesson (Licorish et al., 2018). Wang and Tahir (2020) found that Kahoot enhances a positive learning climate since the formative quizzes are no longer presented formally and formally but instead are engaging and fun throughout for the students.

The features of Kahoot make it more suitable for the primary classroom setting since young children are more

relaxed when they actively participate in what is happening in the classroom. Licorish et al. (2018) identified that students at the primary level appreciate the use of Kahoot, where most of the assessments resemble challenges rather than tests, which helps to decrease anxiety and increase the sense of accomplishment. It is in line with Bandura's (1977) social learning theory, which postulates that direct interaction, as well as the feedback that an individual gets from the social environment, enhances positive learning behaviors. Response time of Kahoot helps the students to know their mistakes instantly, and this makes learning pretty attractive and gripping, besides helping the students to master the content they are studying (Wang & Lieberoth, 2016; Bicen & Kocakoyun, 2018).

Impact of Kahoot on Academic Achievement in Mathematics

Besides, as mentioned above, Kahoot reduces anxiety; researchers also revealed that the use of Kahoot may boost mathematics performance by offering a better learning environment to the students. As noted by Anggoro et al. (2024), meta-analysis identified that, in general, digital game-based learning tools are beneficial for students' performance significantly and more so in a course solving problems like mathematics, which requires the students to be able to reason out and apply what they have learned. Through the use of a game-based approach in Kahoot, students are subjected to review mathematics a number of times in a given period, hence enhancing their ability to comprehend and remember a lot in a certain period, as attested to by Plass et al. (2015). However, this was in line with the view of Wang and Tahir (2020) that Kahoot helps to improve dynamics in a classroom and creates a suitable learning environment that empowers students in the long run.

Those studies related to mathematics education also point to the use of Kahoot in enhancing learners' participation and performance. For instance, Wang and Lieberoth (2016), in their experimental study, established that students who used Kahoot for mathematics tests showed more improvement in the results compared to the students who used regular tests. From these findings, Kahoot's activities facilitate extended cognitive operations and enable students' procedural and conceptual learning in mathematics (Zhang & Huang 2024). Further, Bicen and Kocakoyun (2018) argued that it is helpful in increasing learners' achievement and developing critical thinking and problem-solving skills that are ideal for mathematics.

These findings suggest that more research is required to establish Kahoot's impact on primary students' academic attainment. This research has to involve larger samples and methodologically superior research designs, such as true experimental designs augmented with pre-and post-test results. This study seeks to fill this research gap by offering a nexus of empirical evidence for Kahoot's impact on primary mathematics learning while highlighting the academic performance results.

Conceptual Framework of the Study

The designed conceptual framework is used to assess the research hypothesis (H1) that utilization of Kahoot-based formative assessments will lead to enhanced academic performance in mathematics among primary students compared to traditional formative assessments. The independent variable is the type of formative assessment,

either gamified (Kahoot) or traditional, while the dependent variable is the student's performance on the academic content material, particularly mathematics. Class timing, location of study, data collectors, same formative assessment practices & modules are control variables in this study. However, to reduce the potential confounding effects of formative assessment practices and modules in class, the two groups must be taught lessons using formative assessment practices and their modules. Hence, any variation in performance arises from the assessment method. Sources of variations that may influence the outcomes of the study, such as students' experience with IT, and teacher efficiency, are controlled to the greatest extent possible. Also, variables such as boredom, fatigue and affective traits like emotional intelligence, which are not assessed separately, are postulated to have an indirect effect on students' engagement and performance. In order to control for as many sources of variability as possible, main contextual factors like timing, the range of technology experienced by students, and teacher proficiency are addressed. Other factors like boredom, fatigue and EI are considered but not quantified. Hence, this increases reliability by including standardized locations, orientation sessions, and pretest grouping. These issues are dealt with by having the same teacher and data collectors for the two groups and excluding the absent students. In this way, the framework maintains that results are primarily about the effects of gamified assessments on performance, mainly academic performance.

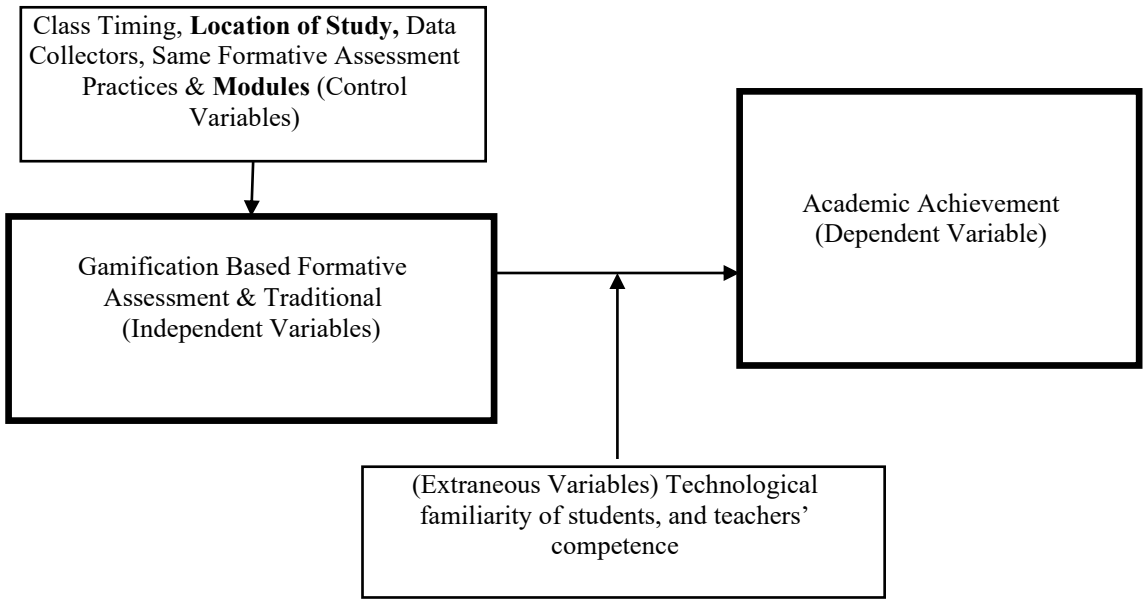

Figure 1. Conceptual Framework of the Study

Methodology

Research Design

This study follows a positivist research paradigm and makes use of a quantitative approach to ensure objectivity and quantifiable outcomes in assessing how gamification-based assessment affects students' mathematical ability. A true experimental research design was used with a pretest-posttest control group to investigate the effect of implementing formative assessment via gamification for primary students' mathematics achievement. This study ideally requires a true experimental research design of the pretest-posttest control group to assure strong internal

validity that also enables causal inference. Therefore, the random assignment part in this design helps to minimize the selection bias and controls for the external variables, such as the prior knowledge, while making the differences in student performance due to the intervention and not the existing disparities (Shadish et al., 2002; Creswell & Creswell, 2018). In addition, this isolates the impact of Kahoot-based formative assessment from confounders (Campbell & Stanley, 2015), including the use of Kahoot, as they include both control and experimental groups.

Population and Sampling Method

The study was based on the target population included 248 5th-grade students of government schools in District Astore with IT labs and internet facilities. Boys High School Gorikote was selected by simple random sampling in order to impartial use and proper implementation of the gamified intervention. The subject students comprised 54 learners who were again divided into twenty-seven each for both the experimental group and the control group. The measured formative assessment, which was administered to the experimental group, was a Kahoot Quiz, which was through gamifying of assessment; the control group, on the other hand, experienced traditional formative assessments. Based on Gay and Airasian (2008) and Fraenkel, Wallen and Hyun (1993) sample selection criteria, the groups were formed so that they could produce statistically valid and reliable samples. The method of study was simple random sampling to offer a noble sample with acceptable amounts of variability and a random selection of students in the control and experimental groups. In the case of pretest scores, they were arranged in such a manner that students were paired according to their aptitude in each group, and a random selection of participants was used to reduce impartiality and reinforce study results. The proposed methodological approach is designed to give strong empirical proof of the influence of game-based assessment on academic performance with the least amount of threat to validity from other extraneous variables.

Setting of the Study

The study was conducted at Boys High School Gorikote Astore, which is situated in Gilgit-Baltistan, Pakistan. A total of 10 Educational institutions were selected on the basis of available IT facilities to integrate gamification in teaching, which were far better. Out of these institutions, 54 male students within the age group of 9-11 years were selected through a lottery method in order to minimize sex bias. The intervention duration was eighty weeks, from October 20 to December 28, in the academic year 2023, to conduct the proper assessment. In a true experimental study, the researcher had assigned groups. One group was the experimental group, which used the gamified formative assessments created using the Kahoot application, while the other group had traditional assessments. The curriculum had twenty-five lessons that were aligned with the national curriculum for 5th-grade mathematics education. It is meticulously reviewed by the subject specialists, ensuring the highest level of expertise in the curriculum design. Both groups completed a pretest, and the same achievement test was used to assess the attaining and retention phases. The feedback mechanism was the same, but the mode of delivery was provided differently: The experimental group received an immediate response using Kahoot, while the control group received a traditional method.

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 MCQs 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 experimental group was given lessons before the break time, while the control group was taught after the break time, and this helped avoid contact between the two groups, hence reducing bias that may come out from the two groups. Both groups were given the same content in order to eliminate instructional differences due to well-structured lesson plans. The questions and feedback for formative assessment were the same between the two groups: the difference was only the delivery of feedback. The experimental group was given Kahoot for quizzes, whereby the results and leaderboard percentages were provided immediately. In contrast, a control group took traditional quizzes where the teacher provided oral feedback and evaluated tasks separately in lessons.

Experts reviewed the instructional content and assessment processes to reduce or eliminate bias. The teacher performed the same scripted lesson to both groups and provided similar amounts of teaching time, test-taking time, and feedback time. In this study, the academic baseline performance of both the control and the experimental group was assessed in a written test administered before the intervention. At the same time, the achievement in mathematics was evaluated after the twenty-five lessons in a controlled environment with the help of a post-test. Formative assessments were incorporated into each session, and equal amounts of effort and time were devoted to both groups. Based on the results of pre-and post-test comparisons, a comprehensive examination of the impact of the proposed approach on increasing the learners' mathematics achievement and motivation through gamification-based formative assessment was made. This approach ensured that the differences observed would result strictly from the intervention. The ethical issues were upheld as follows: consent of parents or caretakers was sought, and participants explained the purpose of the study being conducted. This structured approach was used to establish if gamification can improve learners' academic performance in mathematics education, which is essential knowledge that can be used to enhance effective learning.

Data Collection Instruments

The data collection for the study used the Mathematics Achievement Pretest and Mathematics Achievement Posttest. First, the Mathematics Achievement Pretest and Posttest were constructed from the SNC for Class 5 mathematics in Chapters 1-4 as knowledge, understanding, and application of the subject matter. In an effort to support curriculum implementation and the development of cognitive skills based on formative evaluations, twenty-five lesson plans were developed to help teachers in lesson delivery. In order to improve the quality of the achievement tests, a Table of Specifications (TOS), for short, was created as an ideal guide showing the distribution of the 30 MCQs finalized after item analysis, validity and reliability with respect to difficulty level. The study was undertaken in Boys High School Gorikote Astore with 54 males in fifth Grade selected through purposive sampling, split into an Experimental and Control group of 27 students each. The instructional process

of both groups involved the same lesson plans. In contrast, the experimental group used Kahoot for formative assessments in the form of game-based approaches, while the control group completed paper-based conventional assessments. An immediate posttest that is comparable to the pretest instrument was given after the completion of eight weeks of the intervention.

Validity and Reliability of Mathematics Achievement Test

A Table of Specifications was developed for the Mathematics Achievement Test, and item analysis was performed to evaluate the quality of the Math test items. The CVI of the content validity index was established by aligning the test items with the Single National coursework (SNC) of Pakistan, verified through feedback from 5 experts and elementary group pioneers who played a part in it. The test was designed based on Bloom's Taxonomy, covering cognitive levels: knowledge, comprehension, application, and Content validity. CVI was established by aligning test items with the Single National Curriculum (SNC) of Pakistan, verified through feedback from five experts, including subject specialists and elementary school teachers. Each item, as well as the overall scale, were given a content validation index (CVI) and had a value greater than the accepted value of 0.83.

Table 1. Validation of Mathematics Achievement Pretest Tool

S. No	**Statements**	**Content Validate Index**		
		Aligned	Partially Aligned	Non-Aligned
1	The test items are made appropriately from modules.	05	0	
2	The questions from 1 to 32 measure the lower order thinking skills of students in mathematics subject at 5th grade.	03	2	
3	The achievement test is based on table of specification.	05	0	
4	The stems of multiple choice questions give complete sense and meaning.	05	0	
5	Test items are according to 5th grade level.	05	0	
6	The distractors of MCQs are attractive.	04	01	
7	A sufficient time is fixed for the students to attempt the test.	04	01	

Table 1 shows the content validity index of the mathematics achievement 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 achievement test that developed from the four units of mathematics subject of Single National Curriculum of Pakistan. The mathematics achievement test contained 32 items of MCQs. A module of mathematics subjects and a table of specifications were given to experts to validate the mathematics achievement test appropriately and maintain its quality in the test. The scale contained eight questions: three, Point Likert Scale 1 for aligned, 2 for partially aligned and 3 for non-aligned for the validation of mathematics achievement test. 04 experts were marked in the aligned option, but in items number 2, 6 and 7, some feedback and suggestions by the

03 experts were also marked in the partially aligned option. The achievement test tool was incorporated as per suggestions given by the experts.

Table 2. Reliability of Mathematics Achievement Test

N of Items	Scale	KR-20 Value
6 MCQs/1	Mathematics Achievement Test	0.81

The table 2 shows that internal consistency of the test was confirmed by the reliability analysis, which resulted in a KR-20 value of 0.81, thereby exceeding the recommended minimum value of 0.70 (Gidron, 2020).

Pilot Study

Table 3 demonstrates that pilot study sought to establish the internal validity and reliability of a 90-minute mathematics achievement test of 32 multiple-choice items. A quantitative study was carried out with 24 Fifth Grade male Students from a public primary school, Gorikote Astore and Ahmedabad; the item analysis was done to evaluate the merit of each of the questions. DIF thresholds set by Rejeki et al. (2023) and Elgadal & Mariod (2021) were administered on items these sorted items under easy [DIF ≥ 78%], acceptable [25 ≤ DIF < 78%], and difficult [DIF < 25] categories. Moreover, discrimination indexes were also used to determine how well the questions differentiated apex- and nadir-ability students. The discrimination levels were grouped as follows: excellent (DIS > 0.35), good (0.25 ≤ DIS ≤ 0.34), acceptable (0.21 ≤ DIS ≤ 0.24), and poor (DIS < 0.20) (Rejeki et al., 2023; Elgadal & Mariod, 2021).

Apart from item difficulty and discrimination, distractor efficiency (DE) was measured DE it would define Functional Distractors (FD) as those on which more than 5% of students had put their responses and Non-functional Distractors (NFD) as the ones for which fewer than 5% of students favored it (Rezigalla, 2022; Kumar et al., 2021). Those items that did not pass these requirements were excluded from the test. Regarding the item analysis, all the responses to questions 1 – 30 met the acceptable item analysis criteria, while questions 31 -32 were below the acceptable limits, hence their exclusion. Thus, they guaranteed that the final test would meet the contents and scores of validity and reliability to assess the students' mathematics achievement.

Table 3. Item Difficulty Level, Item Discrimination and Distractor Analysis

Item No.	Item Difficulty Level	Item Discrimination	Distractor Analysis A	B	C	D
Q.1	0.67	0.50	16*	2	4	2
Q.2	0.67	0.50	2	2	4	16*
Q.3	0.58	0.50	2	4	14*	4
Q.4	0.58	0.25	14*	4	4	2
Q.5	0.70	0.25	17*	3	2	2
Q.6	0.67	0.25	4	2	16*	2
Q.7	0.67	0.25	16*	4	2	2

Item No.	Item Difficulty Level	Item Discrimination	Distractor Analysis A	B	C	D
Q.8	0.70	0.25	17*	2	2	2
Q.9	0.67	0.50	2	2	4	16*
Q.10	0.67	0.75	16*	2	4	2
Q.11	0.67	0.50	16*	4	2	2
Q.12	0.58	0.75	14*	4	4	2
Q.13	0.58	0.25	6	2	14*	2
Q.14	0.67	0.25	2	4	2	16*
Q.15	0.67	0.25	2	16*	2	2
Q.16	0.67	0.25	16*	2	2	2
Q.17	0.58	0.25	14*	4	2	4
Q.18	0.67	0.50	16*	2	4	2
Q.19	0.67	0.25	16*	2	2	4
Q.20	0.58	0.25	4	4	14*	2
Q.21	0.58	0.25	2	14*	2	6
Q.22	0.50	0.25	12*	4	4	4
Q.23	0.50	0.50	12*	8	2	2
Q.24	0.58	0.75	2	2	6	14*
Q.25	0.70	0.50	2	3	17*	2
Q.26	0.58	0.50	14*	4	4	2
Q.27	0.58	0.25	2	4	14*	4
Q.28	0.67	0.25	16*	2	4	4
Q.29	0.58	0.75	2	14*	6	2
Q.30	0.58	0.50	14*	6	2	2
Q.31	0.20	0.083	7	8	5*	4
Q.32	0.20	0.083	8	7	5*	4

Results

Normality Test

In order to determine what type of test to conduct, it is first necessary to determine whether the data follows a normal distribution. Commonly used for this purpose are the Shapiro-Wilk and Kolmogorov-Smirnov tests, which are well-suited, respectively, for small sample sizes ($n < 50$) and large samples ($n \geq 50$). A p-value that is more significant than 0.05 means that the hypothesis of normality cannot be rejected. Therefore, we can say that data may be normally distributed. Further, this ensures normality when measures of central tendency and dispersion are interpreted with validity, which in turn leads to valid conclusions in the testing of the hypothesis.

Table 4 presents the results of the normality test, showing that the normal distribution informs the post-test scores for all the assessed variables. The fact that significant values for the control group ($P = 0.098$) and for the

experimental group (P = 0.120) exceed the standard threshold of 0.05 to be regarded as significant supports that. In fact, the control and experimental groups had pretest scores of P = 0.659 for the control group and P = 0.108 for the experimental group. Hence, these findings are verified by all P values > 0.05, support statistical normality. Thus, data analysis using inferential statistics is allowed.

Table 4. Normality Test of Pretest and Posttest of Students Academic Achievement

			Shapiro-Wilk Test		
	Group	N	Statistic	Df	Sig.
Pretest of Students of Students AA	Experimental	27	.936	27	.098
	Control	27	.940	27	.120
Posttest of Students Students' AA	Experimental	27	.972	27	.659
	Control	27	.938	27	.108

Gamification Based Formative Assessment and Academic Achievement of Students

H1: Formative assessments based on Kahoot will significantly increase the academic achievement of primary students in mathematics compared to those who participate in traditional formative assessments.

Table 5 shows the findings of the independent samples t-test. Before measuring the effects of the intervention, the perceptions of academic achievement scores in mathematics of the students in both the experimental group and the control group were measured. Consequently, it was confirmed that the assumption of homogeneity of variances, as tested by Levene, was met.

Table 5. Students' Academic Achievement Before Intervention (Pretest)

Group	N	Mean	Std. Deviation	t	P	Cohen's d
Experimental	27	11.7037	1.38160	.467	.642	0.13
Control	27	11.5185	1.52846			

The results of the current study suggest that the achievement mean score of the experimental group was equivalent to that of the control group, expelling the null hypothesis because t(52) = 0.467 and p = 0.642. According to the p-value obtained, there is no significant difference between the two groups in their pre-intervention academic performance, which is larger than the usual accepted 05 significance level. Also, the effect size of 0.13 obtained from the study is associated with a small ES, as proposed by Cohen (1988). In conclusion, these results suggest that the academic achievement in mathematics, as assessed before the intervention, was equivalent in the experimental and the control groups. Therefore, the random assignment ensured that there were no differences in the children's cognitive abilities prior to the treatment.

Table 6 presents the post-intervention academic achievement score in mathematics for the students of both the experimental and control groups as the results of the independent samples t-test. Analysis of variances showed

that the Levene test's finding supported the assumption of homogeneity of variance. The experimental group produced a higher mean of 25.5185 (SD = 1.74026) among the experimental group and a lower mean of 14.592 (SD = 2.17077) among the control group, $t(52) = 20.406$, $p < 0.001$. In the experimental group, there is a statistically significant post-intervention improvement in academic performance relative to the control group, as the calculated p-value is significantly less than the conventional 0.05 alpha level.

Table 6. Students' Academic Achievement After Intervention (Posttest)

Group	N	Mean	Std. Deviation	T	P	Cohen's d
Experimental	27	21.5556	1.67179	18.078	.000	4.92
Control	27	13.2593	1.70051			

Further, the estimated effect size is 4.92 falls on above Cohen's (1988) standard of a medium effect size equal to 0.50. Based on the findings of this study, it can, be stated that the use of gamification-based formative assessment positively impacts the cognitive skills in mathematics teaching and learning, thus supporting the students in the experimental group in achieving their academic goals. The use of formative assessment that is facilitated by the use of games enhances mastery of the course content since the enhanced client engages their thinking abilities as they play the game with a minimum level of stress. Unlike traditional forms of assessment where students work through an entire problem unknowingly with a wrong concept until the next lesson, the instant results from applications such as Kahoot ensure that wrong concepts are corrected before proceeding with the following problem. Thirdly, the element of competition that is made available through gamification makes students strive to do their best on their assignments more closely associated with motivation. In contrast, the traditional techniques do not have a way to provide instant feedback that enables students to correct their misconceptions at an earlier time, and this has a negative effect on their conceptual learning of mathematics.

Discussion

The findings of this study show that gamification using Kahoot improves formative assessments in mathematics for primary students compared to traditional formative assessments. Furthermore, this affirms the proposed hypothesis (H1) that gamification-based formative assessments enhance students' academic performance in mathematics teaching, which is facilitated by Kahoot's immediate feedback. The results support other recent studies that present the effects that gamification has on learners' performance. For instance, Wang and Tahir (2020) established that carrying out Kahoot as a formative assessment compromised the learning outcomes of the students due to enhanced motivation and hence enhanced learning known to be central to the cognitive development in mathematics. Basuki and Hidayati (2019) identified the mere use of Kahoot for assessment enhances learning engagement levels and focus among students. In light of this, the interactivity of Kahoot enabled learners to pay attention to what was being taught and thereby improved their memory and grasp of complex concepts or units of learning, such as Mathematics. According to the study, academics improve because gamified tools elicit a more profound cognitive procedure. Kahoot's immediate feedback and full interactivity mean that students can quickly change their thinking, which is a scientific way of getting students to absorb information better, according to Wang & Tahir (2020). This paper reviews the investigation made by Ciaramella (2017), which

shows that students who were engaged in learning with the help of Kahoot demonstrated considerably higher satisfaction and fun than those who used the traditional approach. This satisfaction promotes a positive attitude towards learning; hence, the student is more likely to be ready and interested to participate in a lesson. According to the research, competition does make Kahoot attractive because it creates interest and improves concentration as well as motivation during every test. The advantage of playing Kahoot is that it instantly informs the students about the correct answers to the questions and supports learning without pressure and stress.

Additionally, evidence of the effectiveness of gamified assessments to boost learning results was confirmed in this study, given the large effect size of 4.92 (d Cohen). Licorish et al., (2018) in their research, found that students who use Kahoot to access knowledge have better results than those using a quiz since the method provides instant results and includes a set of game-like tasks that relieve the tension of standard tests. Iaremenko (2017) stresses that when the learning facilitators incorporate the games that use Kahoot, the learners' performance will increase. This study focused on English language learners but found the principles broadly applicable: students had higher scores and a better approach to problem-solving when evaluated with Kahoot because they were able to think about the answers and clear up any misunderstandings that they might have had. This feedback given during the game through tools such as Kahoot, for instance, is real-time feedback; it is way better than the delayed feedback familiar with most knowledge assessments.

Moreover, competition in Kahoot prevents students from focusing on external motivation and helps to cultivate intrinsic motivation, which has been proven to be critically important to learning success. For example, Bicen and Kocakoyun (2018) also present that the competition between students in the frame of gamified assessments encourages them to achieve better results, which leads to an increase in students' activity and motivation to solve complex tasks. This type of motivation is pivotal, especially in mathematics, when a student is expected to devote much time to a specific problem.

Last but not least, the assessment part of the gamification approach is less anxiety-inducing than conventional forms of assessment, providing an improved climate for the constructive learning of cognition. Other researchers, Plump and LaRosa (2017), noted that students who embrace the Kahoot-based tests claim to feel less pressured and more engaged, making them a perfect environment in which to learn and excel.

Conclusion and Recommendations

The results of this research reveal that the gamification based formative assessments plays a positively role on students' academic achievement in terms of improving cognitive skills such as knowledge, comprehension and application in mathematics among primary-grade students. This has been due to interest, motivation to acquire a particular knowledge, feedback and low-stress levels, which promote the learning process that entails deeper cognition. Although traditional formative assessment helps students perform academically, the improvement was not much compared to gamification-based formative assessment. However, gamification as a formative assessment showed a significantly higher effect size on students' academic achievement. Therefore, GBFA showed a huge amount of improvement in learning results, particularly in mathematics teaching at the primary

level. The high effect size observed corroborates the formulated hypothesis (H1) that the use of gamification-based formative assessments will produce higher academic achievements compared with the traditional approaches. These results support the current literature findings, thereby showing that the use of the given gamified tools enhances student's intrinsic motivation, problem-solving skills, and retention of complex material:

1. *Integrate Gamified Assessments into Curricula:* Since, the results of this research reveal that the gamified formative assessments as well as Kahoot positively affected achievement in mathematics among primary-grade students. Therefore, Kahoot should be considered one of the effective tools for formative assessments in educational institutions. In addition to promoting uplifted class performance, it improves a positive learning attitude that brings confidence in performance due to the decrease of stress and increase in participation. It is recommended that gamified formative assessment be integrated into mathematics teaching to ensure effective teaching and a good learning environment.
2. *Train Educators on Gamification Techniques***:** Teachers and practitioners in 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.
3. *Encourage Immediate Feedback in Assessments***:** Schools should focus on the usage of assessment methods that provide instant feedback, as is true about Kahoot. This feedback enables students to correct misunderstandings within a short while, thereby consolidating correct knowledge among them. Meanwhile, traditional-based formative assessment is unable to provide prompt feedback to all students in real-time. To provide prompt and constructive feedback in real-time may be provided by gamified formative assessment tools like Kahoot.
4. *Conduct Further Research on Long-term Impacts:* This study provides evidence that, for a short period of 8 weeks, student performance increases with the use of gamified assessment. Future work should examine the differences in learning accomplishment, course retention, and student engagement that occur with the use of gamified assessment over time in different subjects and contexts of education. This study covers the three cognitive skills of Bloom's taxonomy: knowledge, application, and comprehension. Future studies may focus on high-order thinking skills like analysis, synthesis, and evaluation.

Limitations of the Study

1. *Sample Size and Homogeneity***:** This study involved 54 male students in one institute in the fifth grade and thus cannot be generalized. The lack of diversity compromises the generalization of the data and results, especially related to coeducational or multi-institutional settings. This homogeneity is hazardous because it might limit the range of learning responses that might be revealed in an even more heterogeneous group. For example, the performance or participation of female students or students from different socio-economic classes may be different when using gamified instruments such as Kahoot. Thus, the generalizability of the findings to policy or practice still stays limited.
2. *Short Duration of Intervention***:** It was carried out for only eight consecutive weeks. It, therefore, could not enjoy the much-needed sufficient period to identify distinct shifts in the learners' academic outcomes

and interaction. This results in limited generalizability because some of the findings may reflect acute responses to the treatments, for instance, the novelty of gamification, rather than any changes in the cognitive and academic learning systems. For example, more extended periods of analysis could determine whether Kahoot promotes learning behaviors for a long time or is only a one-time engagement tool. From this study, defining the longer-term worth of gamified assessments to teaching and learning, however, demands additional time.

3. *Limited Contextual Scope*: This study was based on a particular geographic location, and hence, the results could be interpreted based on the cultural, technological and educative environment of the area. This limited scope has implications for the study; the findings cannot be exported easily to other regions or countries, which may have different systems of education and distinct access to resources and technology. For instance, in low-resource schools or areas where students have little or no access to the internet, the effectiveness of using Kahoot' may be a lot different. Consequently, the findings have somewhat limited implications for the gamification of education in other countries/cultures.
4. *Single Assessment Method*: The method of assessment involved the use of MCQs only, and therefore, only those limited areas of learning outcomes could be assessed. This methodological limitation affects the results by providing an inflated picture of learning outcomes by focusing more on lower-level skills of learning, such as recall/understanding, without regarding the skills involved in critical thinking/synthesizing/creating. For instance, even though the outcomes are more favorable when it comes to content knowledge, no information is provided concerning the students' skills in relating standard expertise to real-life situations. Therefore, the presented study offers only a partially comprehensive perspective on the educational possibilities of gamified assessment instruments.

Ethical Considerations

The researcher adhered to ethical principles and prioritized respect for participants' rights to minimize any potential violations and ensure the credibility of the study. The key ethical tenets followed are as follows:

1. The school authority granted permission for the study activities to be conducted. Key details of the study were communicated to the parents or guardians of the children regarding the nature of the study, the methods that will be used in conducting the study, the risks involved in participating in the research and the benefits that may accrue to the children and the school.
2. Parents, in a clear demonstration of the voluntary nature of participation, signed a consent letter. This letter granted their child not only the right to participate but also the right to withdraw from the study at any time without the need for further explanation.
3. Individual identification was routinely avoided to protect the privacy of the participants. This was achieved by replacing the participants' names with roll numbers in tests and by advising the students not to share any identifying information.
4. All collected data was secure and used solely in this research project. Measures were taken to ensure the confidentiality of participants' data.
5. The researcher remained fair and honest during the research study, and the participants were treated equally. Hence, favoritism could be removed.

6. No bias was used in the study to observe neutrality and ethical practices among the participants.

Declarations

1. *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.
2. *Conflict of Interests:* The author states that there is neither any conflict of interests 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.
3. *Acknowledgement:* This paper is an extension of a doctoral thesis, meticulously restructured and enhanced to meet high academic standards. It offers a substantive contribution to the scholarly discourse within the field. I want to take this opportunity to extend my most sincere gratitude to my supervisor for giving me unwavering support and guiding me in the right way during the whole process of generating this work. I could not have done this research without their thoughtful comments and moral support. Also, I would like to express my appreciation to the participating students for their cooperation throughout this study and to their parents and the school administration for their support and full cooperation, which enhanced the success of the research study. I would like to express my deep gratitude to them for their passion and involvement regarding this research and; it is with their support that my scholarly pursuit was defined.

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