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Game-Based Learning Utilised Kahoot! Application for Mathematics Literacy and Motivation Among Primary Students: Experimental Study

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ABSTRACT

This study explores how game-based learning using the Kahoot! application can enhance mathematics literacy and learning motivation among primary school students. Employing a quantitative experimental approach, the research involved two student groups: the experimental group engaged in math lessons incorporating Kahoot!, while the control group received conventional teacher-centered instruction. A total of sixty elementary students took part in the study. To evaluate outcomes, mathematics literacy was assessed through pre-tests and post-tests, while a motivation questionnaire gauged students' engagement and attitudes toward learning math. The findings showed that the experimental group experienced significantly greater gains in both mathematics literacy and motivation. The interactive, game-like nature of Kahoot! created a more enjoyable and participatory learning atmosphere, promoting better understanding of mathematical concepts. These results indicate that game-based learning tools like Kahoot! can enhance academic performance and foster a more positive attitude toward mathematics. The study underscores the potential of digital learning innovations to make classrooms more interactive and student-focused, ultimately supporting the development of key mathematical skills in primary education.

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A. INTRODUCTION

In the digital transformation era, education systems worldwide are increasingly embracing technology to enhance mathematics literacy and learning motivation (Ramli et al., 2020). Traditional teaching methods, particularly in mathematics, often fall short in capturing young learners' attention, leading to disinterest, low achievement, and weak mathematical literacy (Bouzid et al., 2021). To address this challenge, educators are turning to game-based learning (GBL) an innovative instructional approach that leverages the motivational power of games to make learning more interactive, enjoyable, and effective (Wijaya et al., 2021).

Mathematical literacy is widely recognized as a potential area for success in today's learning (Lapek, 2020). It involves understanding mathematical concepts and applying them to real-world situations, developing problem-solving abilities, and fostering critical thinking. Early development of mathematics literacy in primary education is essential, as foundational skills acquired at this stage influence future academic performance and everyday decision-making (Ronald, 2020). However, mathematics is frequently perceived by young learners as

abstract, difficult, and disconnected from real life, resulting in reduced enthusiasm and achievement (Gunadi et al., 2022).

One technological tool that has gained significant attention in the instruction section is Kahoot!, a GBL platform that transforms traditional quizzes and lessons into engaging, interactive experiences (Dos Santos et al., 2021). By incorporating elements of competition, instant feedback, and visual appeal, Kahoot! fosters increased student participation, enjoyment, and retention of mathematical concepts. Prior studies have shown that the integration of such digital tools can enhance both cognitive outcomes and learners' attitudes towards mathematics (Rajendran & Mohd Shah, 2020).

Meanwhile, GBL has gained significant recognition as an innovative instructional strategy that enhances student engagement, motivation, and learning outcomes (Yusof & Shahrill, 2021). GBL refers to the use of game elements such as competition, points, challenges, and immediate feedback to create an interactive learning environment where students actively participate in the learning process (Meylani, 2025). Studies have shown that GBL can improve attention, retention, and higher-order thinking skills by transforming passive learning into an enjoyable, immersive experience (Setiawan & Soeharto, 2020).

In primary education, where maintaining attention and interest is particularly challenging, GBL has proven effective in increasing student enthusiasm, particularly in subjects that are often perceived as difficult or abstract, such as mathematics (Vankúš, 2021). By offering a playful and competitive context, games can reduce anxiety, encourage participation, and provide opportunities for both individual and collaborative learning (White & McCoy, 2019).

On the other hand, mathematics literacy extends beyond basic arithmetic skills to include problem-solving, reasoning, interpretation of data, and the application of mathematical concepts in real-life situations (Novita & Herman, 2021). Developing mathematical literacy at the primary level is crucial, as it lays the groundwork for future academic success and for functioning effectively in everyday life (Kaymak & Sautkali, 2022). However, research has indicated that many young learners struggle to develop a positive attitude toward mathematics, often due to conventional instructions that emphasize rote procedural learning over conceptual comprehension (Suwayid & Rezqallah, 2022). As such, there is a growing need for pedagogical approaches that make mathematics both meaningful and engaging for young students.

Subsequently, the integration of digital tools in mathematics education has emerged as a promising solution to address student disengagement and low achievement (Setiawan & Soeharto, 2020). Among these tools, Kahoot! a GBL platform has gained popularity for its simplicity, accessibility, and ability to create lively, interactive learning environments. Kahoot! allows teachers to design quizzes and interactive activities that incorporate immediate feedback, competition, and fun, thus fostering greater student involvement (Pratama et al., 2022). Empirical studies suggest that Kahoot! can significantly improve student motivation, participation, and even learning outcomes in mathematics (Özer & Şad, 2019). The interactive nature of Kahoot! aligns with the needs of digital-native students who are accustomed to visual and game-like experiences. Moreover, Kahoot!'s instant feedback feature allows students to reflect on their learning in real time, which is essential for the development of mathematical literacy (Eva et al., 2022).

Numerous studies have established a positive association between GBL approaches and student motivation, which in turn impacts academic performance (Wong & Wong, 2021). Self-Determination Theory emphasizes that learners are more likely to engage deeply when they experience autonomy, competence, and relatedness three psychological needs often fulfilled through well-designed educational games (Valete, 2023).

In mathematics classrooms, the use of platforms like Kahoot! has been shown to: increase student participation and reduce math anxiety (Dos Santos et al., 2021), support differentiated instruction (Kihwele & Mkomwa, 2023), improve collaborative learning and peer interaction (Yanuarto et al., 2023), and enhance knowledge retention through repeated practice and feedback (Friday, 2024). These results are especially significant in supporting the realization of Sustainable Development Goal 4 (SDG 4), which emphasizes the provision of inclusive, equitable, and high-quality education for every learner (Afolabi, 2021).

This research is designed to experimentally assess the impact of implementing GBL through Kahoot! Application for enhancing mathematics literacy among primary school students. Utilizing a controlled experimental approach, the study explores whether incorporating Kahoot! as a teaching aid can result in better mathematical comprehension, increased student engagement, and superior learning achievements when compared to conventional instructional methods. By examining the connection between technology integration, teaching strategies, and mathematics literacy, this study aims to offer meaningful insights for educators, school administrators, and policymakers who are committed to improving mathematics instruction through innovative approaches. Therefore, this study seeks to assess the level of acceptance toward using the Kahoot app as an educational tool and to evaluate its effectiveness in enhancing primary school students' understanding of mathematics literacy and learning motivation.

B. METHODS

1. Research Design

This research adopted a quantitative experimental design to examine how effective GBL through the Kahoot! The application is for improving mathematics literacy among primary school students (Ishtiaq, 2019). The experimental method was chosen to identify the cause-and-effect link between using Kahoot! and the enhancement of students' mathematical skills and engagement in learning. A pre-test and post-test control group design was implemented, enabling a comparison between students who received GBL and those taught through conventional instructional approaches. Figure 1 depicts the instructional and learning research processes.

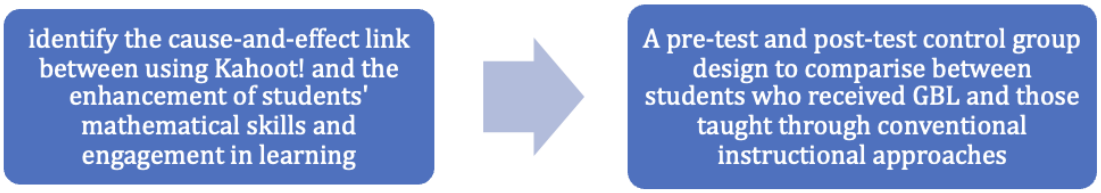

Figure 1. Research Design

2. Participants

The participants in this study were Grade 3 primary school students from two public elementary schools located in West Purwokerto, Indonesia. A total of sixty students were randomly selected and evenly assigned to two groups: the experimental group (n = 30), which received mathematics instruction through the Kahoot! application, and the control group (n = 30), which was taught mathematics using conventional methods without the use of digital technology.

3. Instrumentation

To evaluate the impact of the intervention, the study utilized the following instrument: 1) Mathematics Literacy Assessment: A researcher-developed test consisting of multiple-choice and short-answer items aligned with the national mathematics curriculum for Grade 3. The test assessed students' ability to apply mathematics literacy, consistent with the definition of mathematics literacy (Wulansari & Dwiyanti, 2021); 2) Student Engagement Questionnaire: A validated Likert-scale questionnaire was used to measure students' motivation, and enjoyment of the learning process (Xia et al., 2022); and 3) Observation Checklist: Used by the teacher-researcher to record classroom participation, interaction, and behavioral responses during the intervention (Francis, 2017). All the instruments demonstrated a Cronbach's alpha value greater than .70, indicating acceptable reliability.

4. Procedures

The research was conducted over 4 weeks during regular mathematics classes. The procedure was as follows: (1) Pre-test Phase: Both the experimental and control groups completed the mathematics literacy test before the intervention; (2) Intervention Phase: The experimental group was taught key mathematics topics (e.g., fractions, measurement, basic geometry) using Kahoot!-based quizzes at the end of each lesson to reinforce learning, encourage participation, and provide instant feedback; and The control group was taught the same topics using conventional teaching methods, including textbook exercises and teacher-led instruction without the use of digital games; (3) Post-test Phase: After the completion of the intervention, both groups completed the same mathematics literacy test; and (4) Engagement Survey: Administered to the experimental group to measure their perceptions of the learning experience.

5. Data Analysis

The data gathered in this study were examined using the Statistical Package for the Social Sciences (SPSS) software. Several types of analysis were performed: (1) Descriptive Statistics were used to present a summary of the pre-test and post-test results along with student engagement responses; (2) An Independent Samples t-test was applied to compare the mathematics literacy post-test scores between the experimental and control groups; (3) A Paired Samples t-test was utilized to assess the progress within each group before and after the intervention; and (4) Qualitative observational data were analyzed descriptively to complement and enrich the quantitative results. The threshold for statistical significance was set at $p < 0.05$.

6. Research Questions

In line with the research methodology, the study was guided by the following research questions: (1) What is the nature of the learning process when implementing GBL in the experimental class? (2) Are there significant differences in mathematics literacy outcomes between students taught using GBL and those taught through traditional methods? and (3) How does the motivation level of students in the experimental group compare with that of students in the control group?

C. RESULT AND DISCUSSION

This experimental research aimed to assess the impact of GBL through the Kahoot! Application for improving mathematics literacy in primary school students. The study consisted of two groups: the experimental group, which experienced instruction supported by Kahoot! and the control group, which received conventional teaching without the use of digital tools.

1. RQ 1 – Learning Process of GBL in the Experimental Instructions

The learning process begins with the teacher introducing the mathematics topic of the day, such as fractions, geometry, or problem-solving. The teacher connects the lesson to real-life situations to build relevance and to spark curiosity among the students. Before delving into the main activity, the teacher briefly explains the use of Kahoot! ensuring that all students understand how to join the game using their tablets, smartphones, or school-provided devices. The teacher presents a short explanation or demonstration of the key mathematical concepts. This may include visual aids, manipulatives, or a brief discussion to activate prior knowledge. The objective is to ensure that students have the foundational understanding needed to participate meaningfully in the game-based activity, as shown in Figure 2.

Figure 2. GBL Activity in the Experimental Class

The teacher launches a Kahoot! A quiz specially designed to align with the learning objectives of the lesson. The questions are constructed not only to test procedural knowledge but also to encourage mathematical reasoning, problem-solving, and application of concepts key components of mathematics literacy. Subsequently, students individually or in pairs engage with the quiz on their devices. Each question is displayed on the projector or whiteboard, and students race against time to select their answers. As the game progresses, (1) Immediate feedback is provided after each question, allowing students to learn from mistakes; (2) A points system and leaderboard foster friendly competition, increasing student excitement and

participation; and (3) Discussions may follow challenging questions, with the teacher facilitating reflection and deeper exploration of the correct solutions, as shown in Figure 3.

Figure 3. Teacher Explanation for Kahoot! Application in the Experimental Class

Throughout the activity, the classroom atmosphere is lively and interactive, as shown in Figure 3. Students are visibly more enthusiastic, motivated, and confident in sharing their thinking. The playful format reduces anxiety commonly associated with mathematics, making the subject more approachable and enjoyable. The teacher also praises participation and progress, reinforcing positive attitudes toward learning. After the Kahoot! session, the teacher leads a class discussion to review key concepts, clarify misconceptions, and connect the game questions to broader mathematical ideas. Students are encouraged to reflect on their learning experience and the strategies they used to solve the problems. The session concludes with either a written reflection, additional practice exercises, or an application task that allows students to transfer their newly acquired knowledge to real-life contexts.

2. RQ 2 – Mathematics Literacy Analysis

Before the intervention, both groups completed a mathematics literacy pre-test to establish baseline equivalence. The analysis showed no statistically significant difference between the experimental group ($M = 62.10$, $SD = 8.45$) and the control group ($M = 61.55$, $SD = 9.12$), with an independent samples t-test result of $t(58) = 0.25$, $p = 0.80$. This indicates that both groups started with similar levels of mathematics literacy. After the intervention, both groups completed the mathematics literacy post-test. The experimental group that used Kahoot! showed a marked improvement ($M = 81.75$, $SD = 7.60$) compared to the control group ($M = 70.40$, $SD = 8.95$). An independent samples t-test revealed a statistically significant difference between the two groups' post-test scores: $t(58) = 5.48$, $p < 0.001$. This indicates that the students who experienced GBL through Kahoot! achieved significantly higher mathematics literacy scores than those taught through traditional methods.

Subsequently, a paired sample t-test was conducted to compare the pre-test and post-test results within each group: (1) Experimental Group: Pre-test Mean = 62.10 → Post-test Mean = 81.75; $t(29) = 12.65$, $p < 0.001$ (significant improvement); and (2) Control Group: Pre-test Mean = 61.55 → Post-test Mean = 70.40; $t(29) = 6.72$, $p < 0.001$ (significant but smaller improvement). Therefore, both groups improved over time; however, the improvement in the experimental group was notably larger.

Table 3 indicates a statistically significant difference between the two groups' test scores following the mathematics literacy ($F = 3.244$, $p = .033 < .05$), after accounting for the effect of the covariate (pre-test scores) on the dependent variable (post-test scores). The experimental group achieved an average score of 73.26 with a standard deviation of 11.53, while the control group obtained an average score of 64.65 with a standard deviation of 14.22. In other words, the use of an interactive AR application in mathematics learning produced significantly better outcomes compared to traditional instruction methods, as shown in Table 1.

Table 1. The ANOVA value of the post-test study

Criteria Group	N	M	SD	Adjusted Mean	S.E.	F
Experimental group	30	73.26	11.53	69.42	2.63	3.244
Control group	30	64.65	14.22	72.59	2.03	

Note: *p < .05

3. RQ 3 – Students' Motivation for Learning

The Student Engagement Questionnaire administered to the experimental group showed high levels of positive engagement with Kahoot! based learning: (1) 90% of students reported increased enjoyment of mathematics lessons; (2) 87% felt more motivated to participate in class activities; and (3) 83% believed that using Kahoot! helped them understand mathematics concepts better. Subsequently, Table 2 presents the results of the subsequent covariate analysis. After controlling for the influence of the independent variable (pre-motivation questionnaire) on the dependent variable (post-motivation questionnaire), a significant difference was found between the post-test mathematics motivation levels of the two groups. This is supported by statistical evidence ($F = 8.45$, $p = .004 < .05$). In other words, students who learned using interactive augmented reality applications demonstrated a significantly higher level of motivation compared to those who received traditional instruction combining mathematics with conventional content. Observational data confirmed that the experimental group demonstrated higher levels of participation, collaboration, and enthusiasm compared to the control group.

Table 2. The ANOVA Value of Students' Motivation for Learning

Criteria Group	N	M	SD	Adjusted Mean	S.E.	F
Experimental group	30	72.46	13.63	65.46	2.65	8.451
Control group	30	62.66	14.62	74.42	2.37	

Note: *p < .05

Meanwhile, Figure 3 illustrates that most students achieved results in the top two categories of the Students' Motivation test. For instance, 82.4% of the participants (46 out of 60) found Kahoot! applications to be highly engaging. Additionally, 74.3% of the respondents agreed that the available authoring options helped create Kahoot! applications. It is also notable that a significant majority, 82.6% (47 out of 60), believed that Kahoot! Applications could effectively support motivated learning. Similarly, 84.6% of participants (50 out of 60) felt that Kahoot! Applications are generally suitable for designing educational interventions. Lastly, 62.6% of respondents indicated that integrating Kahoot! Applications with traditional textbooks are relatively easy.

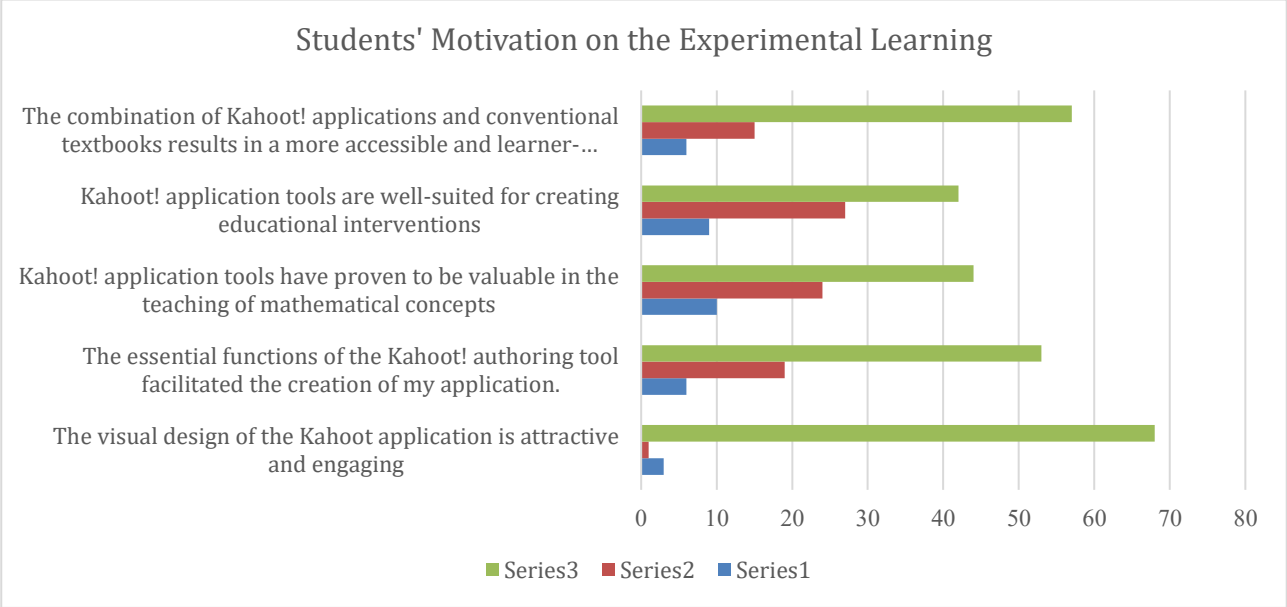

Figure 3. Students' Motivation Evaluation

Many participants shared that they had very positive experiences using Kahoot! Applications. One participant remarked that "both Kahoot! Application tools were easy to learn without any prior programming skills or specialized knowledge," which reflects the general sentiment. Another student noted, "Just three weeks ago, I never imagined I would have the chance to be involved in developing a Kahoot! Applications." With the help of additional learning resources, the student was also able to improve their understanding of fractional mathematics and expressed appreciation for the experience.

Further insights on the use of Kahoot! Applications in mathematics teaching emerged from brief discussions during focus group sessions. Most participants showed strong enthusiasm for Kahoot! Applications and expressed an interest in applying it across various learning contexts. Some students suggested that Kahoot! Tools could help address challenges related to collaborative learning. A majority of students expressed a desire to see Kahoot! Applications are integrated into their regular classroom activities. Additionally, during a discussion on Kahoot! Application development tools, three students highlighted the need for more advanced features in Kahoot! Application platforms, such as combining Unity 3D with Vuforia for enhanced applications. Overall, most students considered Kahoot! The application activity is the most engaging and enjoyable part of their learning experience.

Nevertheless, participants indicated that creating instructional videos was the most demanding and time-consuming part of the process. They also concluded that the existing methods for developing classroom content adequately addressed mathematical topics. Additionally, some students experienced difficulties with the technical components of the software they were using. In most situations, these issues were resolved with assistance from their peers. In a few cases, students opted to seek one-on-one guidance from the teacher to overcome the challenges they faced.

4. Discussion

The results of this study demonstrate that the use of GBL through the Kahoot! app has a significant positive impact on improving mathematics literacy among primary school students. The findings align with existing literature, which emphasizes that digital tools and interactive learning strategies can increase both student engagement and academic achievement (Setiawan & Soeharto, 2020). The experimental group, which received mathematics instruction supported by Kahoot! activities, showed greater improvement in mathematics literacy scores compared to the control group taught using traditional methods (Dos Santos et al., 2021). This suggests that integrating technology-enhanced learning not only enhances cognitive outcomes but also stimulates greater student interest and participation, key factors in developing mathematical reasoning, problem-solving skills, and conceptual understanding.

The significant improvement in the experimental group's performance confirms that GBL can make mathematics more accessible and engaging for young learners. The competitive yet playful nature of Kahoot! provided immediate feedback, allowed for active participation, and supported multiple learning styles. This is consistent with constructivist learning theory, which posits that active engagement and social interaction promote deeper understanding (Vygotsky, 1999). Moreover, the study underscores that assessment through gamified environments can reduce student stress compared to traditional testing, making the assessment process itself more engaging and less intimidating.

An additional contribution of this study is the demonstration that Kahoot! can serve as both a teaching and assessment tool. The platform's immediate feedback and data collection features allow teachers to assess student understanding in real-time, identify misconceptions, and adjust instruction accordingly (Wijaya et al., 2021). This formative assessment function is crucial for supporting personalized learning pathways and fostering student reflection, key principles in contemporary mathematics education. Moreover, the use of gamified quizzes helped to reduce mathematics anxiety, a common barrier to student success, and created a safe environment for learning through trial and error. This finding is supported by Rajendran & Shah (2020), who observed that Kahoot! fosters positive classroom dynamics and student motivation.

The study revealed that the use of Kahoot! positively influenced students' intrinsic motivation, which is critical for sustained engagement in learning mathematics. The competitive elements, instant feedback, and playful atmosphere created by Kahoot! Contributed to increased enthusiasm and active participation. These findings are consistent with Self-Determination Theory, which emphasizes that motivation is enhanced when learners experience autonomy, competence, and enjoyment (Liu et al., 2022). Beyond academic gains, the study also revealed that students in the experimental group exhibited higher levels of motivation and classroom engagement. The use of Kahoot! encouraged collaborative learning, healthy competition, and immediate reinforcement, all of which contributed to sustained student attention and active participation. This is particularly important in primary education, where maintaining focus and enthusiasm can be challenging with traditional lecture-based instruction. High engagement is essential not only for short-term academic performance but also for building long-term positive attitudes towards mathematics, an important factor in

promoting lifelong learning, which is a key aim of Sustainable Development Goal 4 (SDG 4) (Friday, 2024).

Furthermore, the interactive nature of Kahoot! allowed students to learn through exploration and immediate reflection, one of the common barriers to engagement in mathematics learning. As previous studies have suggested Pratama et al. (2022); Setiawan & Soeharto (2020), the use of GBL platforms can significantly improve classroom dynamics and student attitudes, making mathematics more accessible and enjoyable. Beyond motivation, this study found that Kahoot! also contributed to measurable improvements in mathematics literacy, defined as the ability to apply mathematical concepts and reasoning in real-life situations. By incorporating problem-solving tasks, real-world contexts, and time-pressured questions, Kahoot! encouraged students to think critically and apply their mathematical knowledge, rather than merely recalling formulas. This aligns with global educational priorities, such as those emphasized in PISA assessments, where the focus is not only on procedural competence but also on conceptual understanding and application of mathematics in diverse situations (Rajendran & Shah, 2020). The findings suggest that GBL platforms can serve as effective tools not only for practice and review but also for deepening conceptual understanding and enhancing students' problem-solving capabilities.

In conclusion, this study provides strong evidence that GBL using the Kahoot! app can significantly enhance both mathematics literacy and student engagement among primary school learners. By transforming traditional mathematics instruction into an interactive and enjoyable experience, GBL aligns with the goals of Sustainable Development Goal 4 by promoting inclusive, equitable, and quality education (Meylani, 2025). To maximize the benefits of this approach, further research, teacher training, and technology integration are essential components for future educational success.

D. CONCLUSION AND SUGGESTIONS

This study examined the impact of GBL using Kahoot! application on enhancing mathematics literacy and learning motivation among primary school students. The findings demonstrated that the use of Kahoot! significantly improved both students' mathematical understanding and their enthusiasm for learning mathematics compared to traditional teaching methods. The interactive, competitive, and enjoyable nature of Kahoot! effectively fostered active participation, reduced learning anxiety, and encouraged deeper engagement with mathematical concepts. The results confirm that integrating GBL tools into the mathematics classroom can create a more dynamic and inclusive learning environment, supporting both cognitive development and positive attitudes toward mathematics. These outcomes align with the goals of modern education, which emphasize not only content mastery but also student mathematics literacy and learning motivation. The results also support the broader aims of Sustainable Development Goal 4 (SDG 4), which calls for inclusive, equitable, and quality education that promotes lifelong learning opportunities for all. By integrating digital tools like Kahoot! educators can create more engaging, inclusive, and student-centered classrooms that empower learners to develop essential mathematical skills. In light of these findings, it is recommended that teachers, school leaders, and education policymakers consider the adoption of GBL approaches within the mathematics curriculum. Further research is

encouraged to explore the long-term impact of such interventions and their applicability across diverse educational settings.

Based on the findings of this study, the following suggestions are offered for educational practice and future research. For Teachers: (1) Teachers are encouraged to incorporate game-based applications such as Kahoot! into daily mathematics instruction to increase student engagement and improve learning outcomes; and (2) Teachers should design Kahoot! activities that not only review facts but also promote mathematical reasoning, problem-solving, and real-life applications. For Schools: (1) Schools should support the integration of educational technology by providing adequate infrastructure, devices, and professional development to enhance teachers' digital competencies; and (2) Regular use of GBL can be considered as part of a broader strategy to make mathematics more accessible and enjoyable, particularly for students who struggle with traditional approaches. For Future Research**:** (1) Further studies with larger and more diverse samples are recommended to explore the long-term effects of GBL on mathematics achievement and motivation; and (2) Future research could also investigate the use of other digital learning platforms and compare their effectiveness with Kahoot! in various educational contexts.

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