PPD
p-ISSN: 2406-8012 | e-ISSN: 2503-3530
PROFESI PENDIDIKAN DASAR

Kahoot-Based Teams Games Tournament in Developing Students' Mathematical Critical Thinking

Lilik Mustofiyah*, Sutama, Yulia Maftuhah Hidayati, Murfiah Dewi Wulandari
Master's Programme in Primary Education, Universitas Muhammadiyah Surakarta, Indonesia
*Corresponding Author's email: q200239075@student.ums.ac.id

Submitted: 2024-02-01
Revised: 2024-07-15
Accepted: 2024-07-30
DOI: 10.23917/ppd.v11i2.7583

Keywords:

teams games tournament; kahoot; mathematical critical thinking skills; mathematics learning

Abstract

Students' low mathematical critical thinking skills, as shown by the 2022 PISA results and studies, suggest that traditional teaching methods may inadequately develop these abilities. This study examines the effectiveness of combining Kahoot technology with the Teams Games Tournament (TGT) cooperative model to enhance these skills. Using a quasi-experimental pretest-posttest design, fifth-grade students in Madiun City were divided into experimental and control groups. Data were analyzed via General Linear Models (GLM) and MANOVA. Results indicate a significant difference between groups (p=0.011), with the intervention explaining 17.4% of variance in improvement (Partial Eta Squared=0.174). This study provides novel evidence that a Kahoot-based TGT model effectively improves mathematical critical thinking in elementary students—an underexplored area in primary education.

INTRODUCTION

Background of the Study

Critical thinking skills rank among the most essential competencies in the era of globalization and the Fourth Industrial Revolution The World Economic Forum (2022) designates critical thinking as one of the top ten skills essential for future success. Recognizing its significance, education systems worldwide—including Indonesia's—have prioritized the development of these skills as a key educational objective. Such competencies are indispensable for addressing contemporary challenges and enhancing individual competitiveness across diverse fields. In the realm of mathematics education, critical thinking transcends basic problem-solving; it encompasses the capacity to analyze,

synthesize, and systematically interpret information (Facione, 2015). These competencies empower students to engage in logical reasoning, identify patterns, construct coherent arguments, and develop effective solutions to complex problems. Given their importance, the cultivation of critical thinking has emerged as a central goal in mathematics curricula at both national and international levels (Syafril et al., 2020).

One of the primary challenges in contemporary education is the persistent deficiency in students' mathematical critical thinking skills across various academic stages. This challenge is primarily attributed to a continued reliance on traditional, unidirectional pedagogical strategies that prove broadly ineffective. Research indicates that conventional methods, such as lecture-based instruction, fail to adequately nurture critical thinking due to their limited provision for conceptual exploration, inquiry, and independent problem analysis (Sari et al., 2023). Consequently, there is an urgent imperative for innovative, student-centered learning strategies that effectively foster engagement in mathematical critical thinking processes.

The 2022 Programme for International Student Assessment (PISA) reveals persistent challenges in cultivating mathematical reasoning competencies globally, with only 9% of students worldwide attaining advanced proficiency in mathematical thinking (OECD, 2023). In Indonesia, this issue is exacerbated, as students consistently underperform relative to OECD benchmarks. These findings expose significant shortcomings in current pedagogical frameworks and underscore the need for substantial educational reforms. The rationale for adopting the Kahoot-based Teams Games Tournament (TGT) model lies in its potential to address these gaps. TGT, an empirically validated cooperative learning strategy, fosters collaborative problem-solving, while Kahoot—a gamified interactive platform—enhances learner engagement and intrinsic motivation. Their integration offers a promising alternative to conventional methods, which frequently overlook opportunities for analytical and reflective thinking. This study thus investigates the efficacy of this combined approach in advancing critical mathematical thinking skills within primary education, a crucial yet underexplored domain.

Problem of The Study

Initial classroom observations and baseline assessments of critical thinking skills revealed significant deficiencies in students' mathematical problem-solving abilities. Diagnostic data indicated that most students exhibited limited capacity in three key areas: understanding the interconnected nature of mathematical concepts, constructing structured arguments supported by logical reasoning, and generating alternative problem-solving approaches. These limitations were consistently observed across multiple assessments. The analysis of current teaching practices revealed a persistent reliance on conventional instructional methods characterized by teacher-centered lectures and repetitive procedural exercises. Such approaches proved ineffective in developing higher-order cognitive skills, fostering a learning environment that prioritized memorization over conceptual understanding. This traditional pedagogical paradigm resulted in several interconnected challenges, including over-reliance on algorithmic procedures, limited classroom engagement, and underdeveloped mathematical reasoning abilities.

More specifically, these traditional methods led to difficulties in constructing valid logical arguments, recognizing conceptual relationships between mathematical ideas, and formulating mathematical proofs. The identified challenges stem from four primary factors: conventional teaching methods, limited student engagement, inadequate active learning opportunities, and insufficient technology integration in mathematics instruction. Traditional pedagogical approaches that emphasize rote memorization significantly impede students' development of conceptual mathematical understanding. In contrast, research demonstrates that student-centered learning strategies, inquiry-based methods, and effective technology integration enhance mathematical thinking skills (Elvina, 2025).

These educational shortcomings carry profound implications in the contemporary context, where 21st-century competencies—particularly critical thinking, analytical reasoning, problem-solving, and complex logical abilities—are indispensable. Such cognitive skills form the foundation for success in an increasingly globalized and rapidly evolving world, where modern workforce demands require graduates to possess both academic knowledge and the adaptive capacity to address technology-driven, real-world challenges. The persistent deficiency in students' critical mathematical thinking skills demands immediate attention. This challenge necessitates pedagogical approaches that extend beyond mere academic performance to systematically cultivate higher-order cognitive abilities through interactive, context-rich learning experiences. Innovative instructional models that stimulate active participation, enhance motivation, and strengthen critical thinking capacities offer a promising avenue for preparing students to meet contemporary global demands.

Research's State of the Art

The Teams Games Tournament (TGT) cooperative learning model presents an effective approach for enhancing engagement and critical thinking. According to Slavin (1980), as cited in Rahmawati and Purwaningrum (2022), TGT combines collaborative teamwork with competitive academic games, drawing on Vygotsky's social constructivist framework to underscore the cognitive benefits of social interaction. When augmented with digital tools such as Kahoot, this method aligns with Digital Game-Based Learning Theory (Prensky, 2001), which demonstrates that game dynamics can effectively boost both motivation and intellectual growth. Kahoot's interactive, gamified platform elevates learning through competitive quizzes. Its game mechanics—such as scoring systems, rankings, and timed challenges—create a vibrant classroom atmosphere that encourages active participation. Additionally, its compatibility across various devices supports a range of learning contexts. By merging technology with gamification, this modern educational strategy effectively boosts engagement while making the learning process both dynamic and enjoyable. Extensive research has substantiated the efficacy of the Teams Games Tournament (TGT) model in enhancing students' mathematical critical thinking and academic performance. This cooperative learning approach integrates team collaboration, academic competition, and game-based activities to foster an engaging environment that deepens conceptual understanding through active discussion, problem-solving, and group decision-making. Numerous studies confirm TGT's positive effects on learning motivation, social interaction, and higher-order thinking skills in mathematics education (Fauziyah & Anugraheni, 2020; Fitriyani & Supriatna, 2020; Ningsyih et al., 2022; Palupi & Rahayu, 2021; Pratama et al., 2023; Quines, 2017; Samtari & Fakhriyana, 2024; Silva et al., 2019; Sukmawati & Purnamasari, 2016; Suseno et al., 2023; Susilo et al., 2019; Veloo et al., 2016). Sutama et al. (2022) further demonstrate that collaborative learning innovations enhance material comprehension through peer support while concurrently developing essential 21st-century skills, particularly critical thinking.

Similarly, integrating technology in education yields significant benefits. Digital learning media stimulate curiosity, enhance motivation, and improve the understanding of complex concepts while maintaining student engagement (Hidayati et al., 2023). Gamification platforms such as Kahoot have proven particularly effective in cultivating critical thinking skills (Amanda et al., 2024; Holiqi et al., 2022; Maulidah et al., 2020; Mertayasa et al., 2022; Sari et al., 2023; Suryani et al., 2024; Triantafyllou et al., 2024). Research consistently indicates that these tools enhance critical thinking both directly and indirectly—through increased motivation that correlates with improved learning outcomes (Aibar-Almazán et al., 2024; Angkotasan et al., 2019; Ares et al., 2018; Fokides, 2018; Harahap, 2023; Ismail & Mohammad, 2017; Ismail et al., 2018; Kaya & Ercag, 2023; Liu et al., 2020; Licorish et al., 2018; Mattawang & Syarif, 2023; Muzayanati et al., 2022; Petrusly et al., 2024; Plump & LaRosa, 2017; Prasetiani & Sukirman, 2024; Wang & Tahir, 2020).

Gap Study & Objective

Existing research has established the efficacy of the Teams Games Tournament (TGT) model in enhancing learning outcomes and mathematical critical thinking (Fauziyah & Anugraheni, 2020; Fitriyani & Supriatna, 2020; Ningsyih et al., 2022; Palupi & Rahayu, 2021). However, these implementations have predominantly relied on conventional media, without fully integrating gamification technologies. Conversely, while studies have confirmed Kahoot!'s effectiveness in fostering engaging, competitive learning environments (Wang & Tahir, 2020; Licorish et al., 2018), most investigations have focused on its motivational aspects rather than rigorously examining its impact on mathematical critical thinking. Furthermore, some research (Silva et al., 2019; Pratama et al., 2023) has measured only general cognitive outcomes, neglecting systematic critical thinking indicators and prioritizing test score improvements over the development of cognitive processes.

The integration of TGT with gamification platforms such as Kahoot! in elementary mathematics education remains insufficiently explored, despite its potential synergistic benefits for engagement and critical reasoning (Quines, 2017; Suseno et al., 2023). While studies have demonstrated the positive effects of cooperative learning on metacognition (Veloo et al., 2016; Susilo et al., 2019), they have yet to investigate the role of gamification in enhancing critical thinking processes. Recent findings Samtari and Fakhriyana, (2024) indicate that current innovative strategies combining competition and collaboration still fall short in addressing the evaluative and reflective dimensions of critical thinking. The proposed gamification-enhanced cooperative learning model draws on Vygotsky's social constructivist framework, which positions social interaction and cognitively demanding tasks as catalysts for intellectual development. However, empirical validation of this relationship remains scarce. To bridge this gap, this study introduces the Kahoot-Based Teams Games Tournament (KB-TGT) model—a pedagogical innovation designed to foster mathematical critical thinking through active collaboration, reflective reasoning, and gamified engagement, while simultaneously enhancing motivation and participation.

This study advances existing scholarship through its novel integration of Kahoot's gamified platform with the cooperative TGT framework, specifically structured to develop mathematical critical thinking competencies. The investigation evaluatesd the model's efficacy in addressing three persistent challenges in primary mathematics education: (1) comprehension of mathematical word problems, (2) systematic analysis of quantitative information, and (3) application of logical reasoning in problem-solving. The central research question—"What impact does the implementation of the Kahoot-based TGT model have on enhancing primary school students' mathematical critical thinking skills?"—guides an empirical exploration of technology-enhanced collaborative learning strategies that prioritize active cognitive engagement. By addressing pressing needs for evidence-based pedagogical methods that integrate technological innovation, this research contributes to both theory and practice in mathematics education. The findings aimed to substantiate the role of interactive, gamified learning environments in advancing critical reasoning abilities while providing educators with actionable insights for adopting engagement-driven instructional strategies.

METHOD

Type and Design

This study employed a quasi-experimental pretest-posttest control group design to evaluate the efficacy of the Kahoot-enhanced Teams Games Tournament (TGT) model in developing mathematical critical thinking skills. Two intact classes were assigned to either an experimental group receiving the Kahoot-integrated TGT intervention or a control group utilizing conventional TGT methods. The experimental design is outlined in Table 1 below.

Table 1. Pretest–Posttest Control Group Design

Group	Pretest	Intervention	Posttest
Experimental	X_1	T	X_2
Control	X_1	O	X_2

Note:
X_1 = Baseline assessment
X_2 = Post-intervention assessment
T = Kahoot-integrated TGT intervention
O = Conventional TGT instruction

Data and Data Sources

This study was conducted at a private Islamic elementary school in Madiun City, involving 50 fifth-grade students (aged 10–11 years) from two classes. The research site and sample were selected based on the common characteristics of mathematics education in Indonesian primary schools, where traditional teaching methods remain predominant (OECD, 2023). Such methods have been linked to students' limited mathematical reasoning skills. A random sampling technique was employed to ensure equal probability of selection for all population members (Sugiyono, 2013), aligning with quantitative research principles that emphasise generalisability. As Creswell (2012) notes, random sampling enhances the likelihood of obtaining an objective representation of the research population.

Data Collection Technique

Data were collected using pre-test and post-test instruments designed to measure students' mathematical critical thinking abilities before and after the learning intervention. Guided by the frameworks of Ennis (1993) and Facione (1991), the following indicators were assessed: (see Table 2)

Table 2. Critical Thinking Ability Rubric

Indicator	Description	Score
Interpretation	4: Demonstrates comprehensive problem understanding, identifying all key elements. 3: Identifies most elements but omits critical details. 2: Shows partial understanding of key elements. 1: Fails to interpret the problem or omits essential elements.	1-4
Analysis	4: Deconstructs problems effectively, constructing logical, relevant calculations/arguments. 3: Provides mostly sound analytical steps. 2: Offers incomplete analysis with errors. 1: Lacks analysis or presents illogical reasoning.	1-4
Inference	4: Draws accurate, logically supported conclusions. 3: Produces mostly accurate conclusions with limited support. 2: Reaches partially relevant or vague conclusions. 1: Fails to infer conclusions or provides irrelevant responses.	1-4
Evaluation	4: Thoroughly evaluates evidence, identifying errors. 3: Evaluates adequately but lacks depth. 2: Demonstrates limited or flawed evaluation. 1: Provides no evaluation or uncritically accepts evidence.	1-4

A pilot test was conducted to establish instrument validity and reliability. Validity was assessed using Pearson correlation coefficients, comparing individual item scores to total scores. All items showed significant correlations with the total score. For df = 50, the critical r-values were 0.273 ($p < 0.05$) and 0.354 ($p < 0.01$). All calculated r-values exceeded these thresholds, confirming validity. Validity test results confirm that the study's instruments adequately measure the intended constructs. Item P8 demonstrated the highest item-total correlation ($r = 0.791$, $p < 0.01$), indicating its strongest contribution to the construct. Conversely, item P7 showed the lowest correlation ($r = 0.379$, $p < 0.05$) but still met the minimum validity threshold at the 0.05 significance level. Reliability analysis further supports the instrument's internal consistency. The 10-item scale yielded a Cronbach's Alpha of 0.791, surpassing the standard minimum threshold of 0.60. This confirms satisfactory reliability. Table 3 summarizes the reliability statistics.

Table 3. Cronbach's Alpha Reliability Statistics

Reliability Statistics	
Cronbach's Alpha	N of Items
.791	10

Source: SPSS 27

Data Analysis

Pretest and posttest data from the control and experimental groups were analyzed using a General Linear Model (GLM). This analysis included descriptive statistics for an initial data overview, Box's Test of Equality of Covariance Matrices to evaluate equal covariance across groups, Levene's Test of Equality of Error Variances to assess homogeneity of variance for pretest and posttest scores, Multivariate Analysis of Variance (MANOVA) to assess the overall treatment effect, Tests of Between-Subjects Effects to identify significant differences in pretest/posttest scores, and parameter estimates and effect sizes (Partial Eta Squared) to quantify the intervention's impact on critical thinking. The intervention's effectiveness was evaluated by comparing improvements in mathematical critical thinking scores between pretest and posttest.

RESULTS

Prerequisite Assumption Tests

Prior to GLM analysis, prerequisite assumptions (normality and homogeneity of variance) were tested. Data met parametric analysis requirements when p-values exceeded 0.05. Normality test hypotheses were as follows: H_o (null hypothesis): The sample is drawn from a normally distributed population; H_a (alternative hypothesis): The sample is not drawn from a normally distributed population. Homogeneity of variance test hypotheses were: H_o : Variances across groups are equal; H_a : Variances across groups are unequal. (See Table 4 below)

Table 4. Shapiro-Wilk Normality Test for Pretest and Posttest in Control and Experimental Groups

Variable	Class	Shapiro-Wilk		
		Statistic	df	Sig.
Pretest - Critical Thinking Ability	Control Class	.944	25	.187
	Experimental Class	.938	25	.135
Post Test - Critical Thinking Ability	Control Class	.920	25	.051
	Experimental Class	.968	25	.599

Source: SPSS 27

The Shapiro-Wilk normality test results for pretest and posttest critical thinking skills data in both control and experimental groups (using the Kahoot-based Teams Games Tournament approach) showed significance values ($p > 0.05$), confirming normal distribution. (See Table 5 below)

Table 5. Homogeneity Test for Pretest and Posttest of Kahoot-based TGT in Control and Experimental Groups

		Levene Statistic	df1	df2	Sig.
Pretest	Based on Mean	.067	1	48	.798
Posttest	Based on Mean	.464	1	48	.499

Source: SPSS 27

Levene's Test for homogeneity revealed that variances across groups were homogeneous, as all significance values ($p > 0.05$) exceeded the threshold. Specifically, the pretest showed $p = 0.798$, and the posttest yielded $p = 0.499$. These findings confirm that the data meet normality and homogeneity assumptions, validating the use of General Linear Models (GLM) to analyze differences in critical thinking skills before and after the intervention. The General Linear Models (GLM) analysis revealed improvements in critical thinking scores for both groups. The control group's mean pretest score was 7.52 (SD = 2.903), rising to 9.32 (SD = 3.301) posttest, while the experimental group's mean increased from 7.56 (SD = 2.800) pretest to 9.52 (SD = 3.070) posttest. (See Table 6 below)

Table 6. Descriptive Statistics (GLM)

	Category	Mean	Std. Deviation	N
Control Group	Pretest	7.52	2.903	25
	Posttest	9.32	3.301	25
	Total	8.42	3.208	50
Experimental Group	Pretest	7.56	2.800	25
	Posttest	9.52	3.070	25
	Total	8.54	3.072	50

Box's M test confirmed homogeneity of covariance matrices (a prerequisite for multivariate analysis), with Box's $M = 1.163$ and $p = 0.775$ ($p > 0.05$). This indicates equal covariance matrices across groups for the dependent variables (pretest/posttest scores): (See Table 7 below)

Table 7. Box's Test of Equality of Covariance Matrices

Box's M	1.163
F	.370
df1	3
df2	414720.000
Sig.	.775

Source: SPSS 27

To assess the equality of variances within groups, Levene's Test for Equality of Error Variances was conducted. (See Table 8 below)

Table 8. Levene's Test of Equality of Error Variances

		Levene Statistic	df1	df2	Sig.
Control Group	Based on the Mean	.900	1	48	.347
Experimental Group	Based on the Mean	.236	1	48	.629

The results of Levene's Test yielded p-values greater than 0.05 for

both the control and experimental groups, indicating homogeneity of error variances. This confirms that the assumption of homogeneity required for subsequent analyses is met.

Multivariate test results demonstrated a statistically significant effect of group membership (p = 0.011) across all indicators—Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root (see Table 9). The Partial Eta Squared value of 0.174 suggests that approximately 17.4% of the variance in outcomes can be attributed to group differences. (See Table 9 below)

Tabel 9. Multivariate Tests

	Effect	Value	F	Sig.	Partial Eta Squared	Interpretation
Category	Pillai's Trace	.174	4.948[b]	.011	.174	Signifikan (p < 0,05)
	Wilks' Lambda	.826	4.948[b]	.011	.174	Signifikan (p < 0,05)
	Hotelling's Trace	.211	4.948[b]	.011	.174	Signifikan (p < 0,05)
	Roy's Largest Root	.211	4.948[b]	.011	.174	Signifikan (p < 0,05)

To investigate the differences in treatment effects across each dependent variable, a Test of Between-Subjects Effects was conducted. The analysis revealed a statistically significant effect of group category on the outcome measures. For the control group, the F-value was 4.193 (p = 0.046), with a variance contribution of 8% (Partial Eta Squared = 0.080). In contrast, the experimental group yielded an F-value of 5.562 (p = 0.022), accounting for 10.4% of the variance (Partial Eta Squared = 0.104). These results suggest that the experimental group exhibited a slightly greater improvement in outcomes compared to the control group, although the overall effect of group category on total outcome variance was relatively modest. The detailed results are presented in the Table 10 below:

Table 10. Tests of Between-Subjects Effects

Source	Dependent Variable	F	Sig.	Partial Eta Squared	Interpretasi
Category	Control Group	4.193	.046	.080	Significant effect; small variance explained
	Experimental Group	5.562	.022	.104	Significant effect; slightly larger contribution
a. R^2 = 0.080 (Adjusted R^2 = 0.061)					
b. R^2 = 0.104 (Adjusted R^2 = 0.085)					
c. Computed using α = 0.05					

Parameter estimates were examined to further quantify the effect of the treatment on critical thinking skills. In both groups, posttest scores for Category 1 were significantly lower than those for Category 2, with B = -1.800 (p = 0.046) for the control group and B = -1.960 (p = 0.022) for the experimental group. (See Table 11 below)

Table 11. Parameter Estimates

Dependent Variable	Parameter	B	t	Sig.
Control Group	Intercept	9.320	14.993	.000
	[Category = 1]	-1.800	-2.048	.046
	[Category = 2]	0[a]	.	.
Experimental Group	Intercept	9.520	16.200	.000
	[Category = 1]	-1.960	-2.358	.022
	[Category = 2]	0[a]	.	.
a. Parameter set to zero (redundant).				
b. Computed using α = 0.05				

The multivariate General Linear Model (GLM) analysis revealed statistically significant differences between the control and experimental groups in their pretest and posttest outcomes. Specifically, both groups demonstrated significantly lower mean posttest scores for Category 1 compared to Category 2, with the experimental group exhibiting a slightly greater decrease (B = -1.960, p = 0.022) than the control group (B = -1.800, p = 0.046). Although the proportion of variance accounted for by these group differences remains relatively small, the intervention implemented in the experimental group resulted in a modest yet statistically significant improvement over the control group. These findings highlight the meaningful, albeit limited, impact of group category on the development of critical thinking skills.

DISCUSSIONS

The findings of this study demonstrate that integrating the Teams Games Tournament (TGT) model with Kahoot positively impacts students' mathematical critical thinking abilities. Quantitative analysis revealed statistically significant differences in posttest critical thinking scores between the control group, which employed a conventional TGT approach, and the experimental group, which incorporated Kahoot into the TGT framework. These results underscore the potential of embedding interactive technology within cooperative learning models to enhance pedagogical effectiveness and student engagement. Furthermore, the integration of Kahoot with the TGT model fosters a dynamic, motivating, and immersive learning environment, aligning with prior research on technology-enhanced instructional strategies (Wang & Tahir, 2020).

Statistical analysis via the General Linear Model (GLM) indicated a significant effect of group category on posttest outcomes ($p = 0.011$, $\eta^2 = 0.174$). The experimental group achieved a higher mean posttest score (M = 9.52, SD = 3.070) compared to the control group (M = 9.32, SD = 3.301), with 17.4% of the variance in outcomes attributable to the intervention—specifically, the incorporation of Kahoot into the TGT model. While the effect size is moderate, this finding emphasizes the critical role of interactive technology in cultivating higher-order thinking skills, consistent with existing literature (Sulistyowati & Asriati, 2024). Further analysis of the Between-Subjects Effects revealed that the control group yielded an F-value of 4.193 ($p = 0.046$), whereas the experimental group, which employed Kahoot, yielded an F-value of 5.562 ($p = 0.022$). These findings indicate that the experimental group exhibited a more substantial improvement in critical thinking scores compared to the control group. Although the group effect accounted for a comparatively small portion of the total variance, it nonetheless underscores a positive impact of the intervention. Consequently, the integration of interactive quiz-based technology into the learning process has proven effective in enhancing student engagement and fostering the development of mathematical critical thinking skills.

The parameter estimation analysis demonstrated that the control group achieved a lower mean posttest score than the experimental group, with regression coefficients of B = -1.800 ($p = 0.046$) for the first category and B = -1.960 ($p = 0.022$) for the second category in the experimental group. This evidence suggests that students engaging with Kahoot attained superior performance in assessments of critical thinking skills relative to their counterparts in the control group. This finding highlights the significant contribution of Kahoot as a learning tool in strengthening students' mathematical critical thinking abilities. These empirical results align with Vygotsky's (1978) theory of social constructivism, which emphasizes the critical role of social interaction in learning and cognitive development. Social interaction serves as a foundation for cultivating cognitive abilities, enabling students to develop higher-order thinking skills through peer collaboration or teacher guidance (Vygotsky, 1978; Zahroni et al., 2024). Within this framework, the integration of Kahoot into the TGT model fosters a collaborative, engaging, and motivating learning environment, thereby supporting the advancement of critical thinking skills

The study's findings are consistent with previous research by Sutama et al. (2022), which demonstrated that collaborative learning models significantly enhance students' analytical capabilities. In a similar vein, Fauziyah and Anugraheni (2020) found that active participation in group discussions within cooperative learning environments markedly improves both analytical and problem-solving skills. These results also align with literature indicating that gamification-based learning—exemplified by Kahoot—substantially increases student motivation (Suryani et al., 2024). This supports the conclusions drawn by Wang and Tahir (2020), whose meta-analysis of 93 studies revealed that Kahoot consistently fosters higher levels of motivation, participation, and overall academic performance. The gamification features inherent in Kahoot, such as scoring systems, leaderboards, and time constraints, provide cognitive stimulation that prompts students to engage critically with the learning process, thereby promoting a more rigorous approach to solving mathematical problems.

Furthermore, the present findings echo those of Maulidah et al. (2020), who showed that gamification via interactive quizzes positively impacts critical thinking skills in mathematics. This is further corroborated by Suryani et al. (2024), who confirmed that Kahoot-based learning significantly enhances critical thinking in mathematical contexts. By offering an engaging and interactive platform, Kahoot facilitates a deeper understanding of abstract mathematical concepts. Licorish et al. (2018) found that Kahoot enhances students' concentration and fosters the development of rapid thinking strategies, which are key indicators of critical thinking ability. Similarly, Korkmaz and Öz (2021) demonstrated that the integration of gamification with cooperative learning models not only increases intrinsic motivation but also strengthens critical thinking skills and deepens conceptual understanding. Furthermore, studies by Plump and LaRosa (2017) and Bicen and Kocakoyun (2018) suggest that incorporating games into educational settings promotes active learning and enhances student interaction. Overall, the present study affirms that Kahoot-based learning methods can improve students' critical thinking skills. Although the effect size was moderate, the findings underscore Kahoot's value as an effective pedagogical tool, particularly in enhancing motivation and engagement. Nevertheless, further research is required to explore the mechanisms underpinning improvements in critical thinking and to identify strategies for maximising the educational potential of technology**.**

CONCLUSION

This study demonstrates that integrating Kahoot into the Teams Games Tournament (TGT) learning model significantly enhances the mathematical critical thinking skills of students in the experimental group compared to the control group. Statistical analysis revealed a statistically significant difference between pretest and posttest outcomes ($p < 0.05$), with a Partial Eta Squared value of 0.174 indicating that group category differences accounted for approximately 17.4% of the variance in learning outcomes. Although the effect size is modest, these findings underscore the potential of Kahoot to foster critical thinking skills through technology-enhanced collaborative learning. The study contributes new empirical evidence on the integration of gamification and cooperative learning in mathematics education, while proposing an innovative, engaging instructional approach for students. Its novelty lies in combining the TGT model with the Kahoot digital platform—an area that has received limited in-depth exploration in the context of developing mathematical critical thinking skills at the primary education level. The primary contribution of this research is its advancement of digital pedagogy by introducing a technology-driven, interactive learning framework that supports students' cognitive development. This study presents several limitations that should be considered when interpreting its findings. Firstly, the sample—comprising only 50 students from two classes within a single primary school in Madiun City—limits the generalisability of the results to wider populations or varied geographical contexts. Secondly, the short duration of the intervention may not adequately capture the long-term effects of the Kahoot-based TGT model on students' critical thinking skills. Educators are encouraged to integrate technology into their pedagogical practices to foster a

more dynamic and effective learning environment. It is recommended that educational institutions offer professional development opportunities to equip educators with the skills necessary to effectively utilise technology-based tools such as Kahoot. This study underscores the need for continued investigation into the role of technology in education. Future research should build upon these findings by examining the effectiveness of technology-enhanced learning approaches across a range of educational contexts and subject areas.

REFERENCES

Aibar-Almazán, A., Castellote-Caballero, Y., Carcelén-Fraile, M. del C., Rivas-Campo, Y., & González-Martín, A. M. (2024). Gamification in the classroom: Kahoot! As a tool for university teaching innovation. *Frontiers in Psychology*, 15. https://doi.org/10.3389/fpsyg.2024.1370084

Amanda, A. P. D., Zuliana, E., & Riswari, L. A. (2024). Application of Kahoot Online Media to Critical Thinking in Mathematics for Grade V Students of SDN 1 Tambahrejo. *RANGE: Jurnal Pendidikan Matematika,* 6(1), 96–111. https://doi.org/10.32938/jpm.v6i1.7380

Angkotasan, N., Tonra, W. S., & Taib, S. (2019). The excess of Kahoot for pre-service teacher as an evaluation tool. *International Journal on Teaching and Learning Mathematics,* 2(1), 15–20. https://doi.org/10.18860/ijtlm.v2i1.9115

Ares, A. M., Bernal, J., Nozal, M. J., Sánchez, F. J., & Bernal, J. (2018). Results of the use of Kahoot! gamification tool in a course of Chemistry. P*roceedings of the Fourth International Conference on Higher Education Advances (HEAd'18). Polytechnic University of Valencia.* https://doi.org/10.4995/head18.2018.8179

Bicen, H., & Kocakoyun, S. (2018). Perceptions of students for gamification approach: Kahoot as a case study. *International Journal of Emerging Technologies in Learning, 13*(2), 72–93. https://doi.org/10.3991/ijet.v13i02.7467

Creswell, J. W. (2012). *Planning, conducting, and evaluting quantitative and qualitative research (4th ed.). In Pearson Education*. Pearson Education.

Elvina, N. (2025). Factors affecting high school students ' mathematical thinking skills and solutions. *FiHeSu International Journal of Education and Development Research, 2*(1), 34–42. https://ejournal.fihesu.com/index.php/FIJEES/article/view/25

Ennis, R. H. (1993). Critical thinking assessment. *Theory Into Practice,* 32(3), 179–186. https://doi.org/10.1080/00405849309543594

Facione, P. A. (1991). *Using the california critical thinking skills test in research, evaluation, and assessment.* California Academic Press, 1–20.

Facione, P. A. (2015). Critical thinking: What it is and why it counts. *Insight Assessment, 5*(1), 1–30. www.insightassessment.com

Fauziyah, N. E. H., & Anugraheni, I. (2020). Pengaruh model pembelajaran TGT (Teams Games Tournament) ditinjau dari kemampuan berpikir kritis pada pembelajaran tematik di sekolah dasar. *Jurnal Basicedu,* 4(4), 850–860. https://doi.org/10.31004/basicedu.v4i4.459

Fitriyani, Y., & Supriatna, N. (2020). Effect of effectiveness of application used cooperative learning model type numbered head together (NHT), teams games tournament (TGT) and course review horay (crh) against increased critical thinking skill of students. *The 2nd International Conference on Elementary Education,* 2(1), 955–968. http://proceedings.upi.edu/index.php/icee/article/view/707/623

Fokides, E. (2018). Digital educational games and mathematics. Results of a case study in primary school settings. *Education and Information Technologies, 23*(2), 851–867. https://doi.org/10.1007/s10639-017-9639-5

Harahap, A. (2023). Efektivitas aplikasi kahoot sebagai media pembelajaran dalam menghadapi era society 5.0. *PIONIR : Jurnal Pendidikan,* 12(1), 29–44. http://dx.doi.org/10.22373/pjp.v12i1.15225

Hidayati, Y. M., Kusuma, A. A. S., Wibosono, M. E. W., & Safitri, S. I. (2023). Unlocking math skills: The argeo math app for enhanced mathematical problem-solving. *Profesi Pendidikan Dasar, 82*–97. https://doi.org/10.23917/ppd.v10i2.2837

Holiqi, E. S., Maryani, & Prastowo, S. H. B. (2022). Development of contextual assessment instruments for students' critical thinking skills using kahoot quiz. *Jurnal Pendidikan Fisika*, 10(2), 176–186. http://journal.uin-alauddin.ac.id/indeks.php/PendidikanFisika

Ismail, M. A.-A., & Mohammad, J. A.-M. (2017). Kahoot: A promising tool for formative assessment in medical education. *Education in Medicine Journal*, 9(2), 19–26. https://doi.org/10.21315/eimj2017.9.2.2

Ismail, M. E., Sa'Adan, N., Samsudin, M. A., Hamzah, N., Razali, N., & Mahazir, I. I. (2018). Implementation of the gamification concept using KAHOOT! among TVET Students: An observation. *Journal of Physics: Conference Series,* 1140(1). https://doi.org/10.1088/1742-6596/1140/1/012013

Kaya, O. S., & Ercag, E. (2023). The impact of applying challenge-based gamification program on students' learning outcomes: Academic achievement, motivation and flow. *Education and Information Technologies*, 28(8), 10053–10078. https://doi.org/10.1007/s10639-023-11585-z

Licorish, S. A., Owen, H. E., Daniel, B., & George, J. L. (2018). Students' perception of Kahoot!'s Influence on Teaching and learning. *Research and Practice in Technology Enhanced Learning*, 13(9), 1–24. https://doi.org/https://doi.org/10.1186/s41039-018-0078-8

Liu, Z. Y., Shaikh, Z. A., & Gazizova, F. (2020). Using the concept of game-based learning in education. *International Journal of Emerging Technologies in Learning*, 15(14), 53–64. https://doi.org/10.3991/ijet.v15i14.14675

Mattawang, M. R., & Syarif, E. (2023). Dampak penggunaan kahoot sebagai platform gamifikasi dalam proses pembelajaran. *Journal of Learning and Technology*, 2(1), 33–42. https://doi.org/10.33830/jlt.v2i1.5843

Maulidah, E., Syaf, A. H., Rachmawati, T. K., & Sugilar, H. (2020). Berpikir kritis matematis dengan KAHOOT. *Jurnal Analisa*, 6(1), 19–27. https://doi.org/10.15575/ja.v6i1.8516

Mertayasa, I. M., Astawan, I. G. A., & Gading, I. K. (2022). Implementasi model pembelajaran berbasis media gamifikasi- kahoot berbasis hots terhadap penguasaan konsep dan keterampilan berpikir kritis siswa SD. *Jurnal Ilmiah Pendidikan Citra Bakti*, 9(2), 355–365. https://doi.org/10.38048/jipcb.v9i2.686

Muzayanati, Apriliyanti , Maemonah, P. P. (2022). Efektivitas aplikasi game kahoot dalam meningktkan motivasi dan hasil belajar siswa pada materi matematika di sekolah dasar. 11(January), 161–173. https://repository.ar-raniry.ac.id/id/eprint/33343/1/Muhammad%20Tanwir,%20180212049,%20FTK,%20PTI,%2082259041060.pdf

Ningsyih, S., Hairunisa, H., Fatimah, N., & Ulfa, M. (2022). The effect of the team games tournament model with the traditional game media to train critical thinking ability in elementary school students. *Jurnal Pijar Mipa, 17*(1), 62–66. https://doi.org/10.29303/jpm.v17i1.3182

OECD. (2023). Pisa 2022. In PISA 2022 Results: The state of learning and equity in education: Vol. I. PISA *OECD Publishing*. https://www.oecd.org/en/publications/pisa-2022-results-volume-i_53f23881-en.html

Palupi, I. D. R., & Rahayu, T. S. (2021). Efektivitas model pembelajaran group investigation (GI) dan teams games tournament (TGT) ditinjau dari kemampuan berpikir kritis matematika. *Thinking Skills and Creativity Journal, 4*(1), 10–20. https://doi.org/10.23887/tscj.v4i1.33451

Petrusly, F. L. K., Bani, M. D. S., Mahfud, T., & Zulkarnain. (2024). The effect of gamification using Kahoot on students' critical thinking abilities: The role of mediating learning engagement and motivation. Educational Administration: Theory and Practice, 30(5), 953–963. https://doi.org/10.53555/kuey.v30i5.1524

Plump, C. M., & LaRosa, J. (2017). Using Kahoot! in the classroom to create engagement and active learning: A game-based technology solution for elearning novices. *Management Teaching Review,* 2(2), 151–158. https://doi.org/10.1177/2379298116689783

Pratama, D. A., Kusmiyati, Tri Ayu Lestari, & Muhlis. (2023). The effect of cooperative learning model TGT-type assisted by crossword puzzle media on biology concept mastering. *Jurnal Pijar Mipa, 18*(5), 676–680. https://doi.org/10.29303/jpm.v18i5.5190

Prensky, M. (2001). The games generations: How learners have changed. *Computers in Entertainment, 1(*1), 1–26. http://portal.acm.org/citation.cfm?doid=950566.950596

Quines, E. (2017). Effectiveness of cooperative learning approach in developing critical thinking skills of secondary students. *In Empowering 21st Century Learners Through Holistic and Enterprising Learning (pp. 115–123). Springer Singapore*. https://doi.org/10.1007/978-981-10-4241-6_12

Rahmawati, F. A., & Purwaningrum, J. P. (2022). Penerapan Teori Vygotsky dalam pembelajaran matematika. *Jurnal Riset Pembelajaran Matematika, 4*(1), 1–4. https://doi.org/10.55719/jrpm.v4i1.349

Samtari, N., & Fakhriyana, D. (2024). Team games tournament and means-ends analysis: Learning types in improving mathematical critical thinking. *Kalamatika: Jurnal Pendidikan Matematika,* 9(1), 1–14. https://doi.org/10.22236/kalamatika.vol9no1.2024pp1-14

Sari, N., Irwan, & Candra, A. A. (2023). Pengaruh penggunaan media pembelajaran game edukasi Kahoot terhadap kemampuan berpikir kritis siswa pada mata pelajaran PPKN di kelas X Perhotelan SMK Negeri 6 Kota Jambi. AoEJ: Academy of Education Journal, 14(2), 606–615. https://doi.org/10.47200/aoej.v14i2.1815

Silva, H., Lopes, J., & Dominguez, C. (2019). Enhancing college students' Critical thinking skills in cooperative groups. *Communications in Computer and Information Science, 993,* 181–192. https://doi.org/10.1007/978-3-030-20954-4_13

Sugiyono. (2013). *Metode Penelitian Kuantitatif, Kualitatif, dan R & D*. Alfabeta, CV.

Sukmawati, R. A., & Purnamasari, W. (2016). Pembelajaran matematika menggunakan model pembelajaran kooperatif tipe teams games tournaments (TGT) di kelas VIII SMP. *EDU-MAT: Jurnal Pendidikan Matematika,* 4(1), 86–94. https://doi.org/10.20527/edumat.v4i1.2293

Sulistyowati, C., & Asriati, N. (2024). Pemanfatan teknologi untuk meningkatkan efektivitas pembelajaran dan keterlibatan belajar di era digital. *Jurnal Ilmiah Pendidikan Citra Bakti*, 11(4), 1176–1188. https://doi.org/https://doi.org/10.38048/jipcb.v11i4.4542

Suryani, H., Setiani, A., & Agustiani, N. (2024). Gamification of mathematics teaching materials to improve problem solving and critical thinking ability: The experts' assessment. *Educational Administration: Theory and Practice,* 30(4), 819–833. https://doi.org/10.53555/kuey.v30i4.666

Suseno, B., Setiawan, I., & Pratiwi, R. T. (2023). The Influence of the cooperative learning model type of teams games tournaments (TGT) with the tournament table game on students' critical thinking abilities. *International Journal of Management and Business Intelligence*, 1(2), 87–106. https://doi.org/10.59890/ijmbi.v1i2.204

Susilo, N. H., Wijayanti, A., & Artharina, F. P. (2019). Penerapan permainan what's in here berbasis model tgt untuk menumbuhkan kemampuan berpikir kritis siswa. *Jurnal Ilmiah Sekolah Dasar,* 3(2), 125–134. https://doi.org/10.23887/jisd.v3i2.17756

Sutama, S., Fuadi, D., Narimo, S., Hafida, S. H. N., Novitasari, M., Anif, S., Prayitno, H. J., Sunanih, S., & Adnan, M. (2022). Collaborative mathematics learning management: Critical thinking skills in problem solving. International Journal of Evaluation and Research in Education, 11(3), 1015–1027. https://doi.org/10.11591/ijere.v11i3.22193

Syafril, S., Aini, N. R., Netriwati, Pahrudin, A., Yaumas, N. E., & Engkizar. (2020). Spirit of mathematics critical thinking skills (CTS). *Journal of Physics: Conference Series*, 1467(1). https://doi.org/10.1088/1742-6596/1467/1/012069

Triantafyllou, S. A., Sapounidis, T., & Farhaoui, Y. (2024). Gamification and Computational Thinking in Education: A systematic literature review. *Salud, Ciencia y Tecnologia - Serie de Conferencias*, 3(c). https://doi.org/10.56294/sctconf2024659

Veloo, A., Md-Ali, R., & Chairany, S. (2016). Using cooperative teams-game-tournament in 11 religious school to improve mathematics understanding and communication. Malaysian Journal of Learning and Instruction, 13(2), 97–123. https://eric.ed.gov/?id=EJ1134733

Vygotsky. (1978). *Mind in Society . The Development of Higher Psychological Processes*. Harvard University Press.

Wang, A. I., & Tahir, R. (2020). The effect of using Kahoot! for learning – A literature review. *Computers and Education*, 149. https://doi.org/10.1016/j.compedu.2020.103818

World Economic Forum. (2022). The future of jobs report 2020 | world economic forum. The Future of Jobs Report. https://www.weforum.org/reports/the-future-of-jobs-report-2020/digest

Zahroni, A., Suciati, Efendi, M., Mustofa, N. H., Susetyarini, R. E., & Baiduri. (2024). *Konstruktivisme: Pembelajaran Berpusat Pada Siswa.* In Perkumpulan Rumah Cemerlang Indonesia: Anggota IKAPI Jawa Barat (1st ed.).