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The effect of contextual teaching and learning model with ethnomathematics approach on students' conceptual understanding and critical thinking

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ABSTRACT

Background: Mathematics learning demands not only conceptual understanding but also critical thinking skills. However, studies in Indonesian classrooms have shown that students often struggle with both abilities. A possible cause is the use of teacher-centered approaches that do not facilitate student engagement or meaningful learning experiences.

Aim: This study aims to investigate the effect of the Contextual Teaching and Learning (CTL) model integrated with an ethnomathematics approach on students' conceptual understanding and critical thinking skills in mathematics.

Method: This research employed a quantitative approach with a quasi-experimental design. The sample consisted of 60 ninth-grade students from two different classes selected using simple random sampling. Data were collected through validated test instruments and analyzed using Multivariate Analysis of Variance (MANOVA) with a significance level of 0.05.

Results: The findings showed that both the conceptual understanding and critical thinking skills of students in the experimental group improved significantly compared to the control group. The MANOVA results indicated a significance value of 0.000 (< 0.05), confirming a significant effect of the CTL model with ethnomathematics on both dependent variables. The average N-Gain score in the experimental class was higher (0.68) than in the control class (0.62).

Conclusion: The implementation of the CTL model with an ethnomathematics approach has a positive and significant effect on improving students' conceptual understanding and critical thinking in mathematics. This approach enables students to relate mathematical content to cultural contexts, making learning more meaningful and engaging.

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INTRODUCTION

Persistent challenges in mathematics education continue to impact student performance in Indonesia. This is evident in poor international achievement rankings, comparatively lower national examination scores in mathematics, and widespread student disengagement from the subject. Despite its substantial presence in the curriculum, mathematics remains one of the least preferred disciplines among learners (Wahyu, 2016; Hafizah Delyana, 2015). Such circumstances underscore the disconnect between the intended educational outcomes and the realities of classroom implementation. As argued by Roni Hariyanto Bhidju (2020), education should cultivate the competencies necessary for active societal participation. Yet, traditional instruction dominated by textbook reliance often fails to provide students with the opportunity to engage critically and meaningfully with content. In an era of accelerating technological progress, education must respond both adaptively and responsibly (Chairul Anwar et al., 2018), striving to continually enhance human capacity and potential (Roqid, 2016). Unfortunately, such ideals are not consistently realized within current mathematics teaching practices.

Preliminary data from this study revealed that only 23 of 60 ninth-grade students achieved the minimum passing grade (KKM = 70) in assessments of conceptual understanding, leaving the majority below the expected threshold. Students frequently demonstrated an inability to present diverse solution strategies, provide logical justifications, or interpret mathematical problems contextually. These findings indicate a deficiency in conceptual understanding, defined as the capacity to comprehend relationships, operations, and foundational mathematical structures. In parallel, critical thinking (another fundamental skill) also appears underdeveloped. Alkat Yanwar (2018) and Wahyu (2019) report that many learners encounter significant obstacles when confronted with non-routine problems requiring analytical reasoning. Consistent with this, the current study's pre-test results show that only 25 students met the criteria for critical thinking proficiency, while 35 did not.

Addressing these shortcomings necessitates a paradigm shift toward instructional models that are both student-centered and contextually relevant. One pedagogical approach aligned with this vision is Contextual Teaching and Learning (CTL), which seeks to bridge academic content with students' everyday experiences, thereby promoting deeper engagement and understanding (Yuliana Eka, 2018). According to Elaine (2013), CTL aligns with brain-based learning frameworks, enabling students to construct knowledge through meaningful connections. Shoimin (as cited in Widyaningrum, 2021) outlines six integral components of CTL—constructivism, inquiry, learning community, modeling, reflection, and authentic assessment—each of which supports active learning processes. Nevertheless, as Anisa (also in Widyaningrum, 2021) notes, implementing CTL effectively demands intensive facilitation and may disadvantage students who require more structured guidance.

To enhance the contextual nature of CTL, the integration of ethnomathematics has emerged as a promising direction. Ethnomathematics involves embedding cultural knowledge and local practices into the mathematics curriculum, making learning more relevant and accessible to students (Shirley, 2008; Rizki Nanda Arista, 2016). D'Ambrosio (1999) contends that ethnomathematics encompasses epistemological, historical, and pedagogical dimensions that enrich the teaching and learning of mathematics. Kilpatrick et al. (2002) further assert that grounding mathematical instruction in cultural contexts can significantly strengthen relational understanding. Empirical studies have confirmed the benefits of CTL for fostering conceptual understanding (Endang Putri Ningsih, 2018), increasing student participation (Rusyda Nurul Afifah, 2016), and addressing mathematical misconceptions (Arika Hasim Asari & Toto, 2014; Merdiana Dina, 2014).

However, despite these findings, the integration of CTL with an ethnomathematics perspective remains underexplored—particularly in relation to its potential to simultaneously advance students' conceptual understanding and critical thinking. This study, therefore, seeks to examine the impact of applying the Contextual Teaching and Learning model combined with an ethnomathematics approach on students' mathematical understanding and reasoning skills.

METHOD

This research adopted a quantitative approach with a quasi-experimental design to examine the effect of instructional interventions. The sample was selected using simple random sampling, involving 60 ninth-grade students from classes IXA and IXC during the 2022/2023 academic year. The subject matter explored in the study was Geometric Transformation, a key topic in the middle school mathematics curriculum.

To assess the targeted learning outcomes, the study employed two instruments: a conceptual understanding test and a critical thinking test. Both instruments were validated by subject-matter experts to ensure content appropriateness. A pilot test was subsequently conducted to examine the quality of the items. The tests were then analyzed for validity, reliability, item difficulty, and discrimination power to meet psychometric standards prior to full deployment. Data collection was carried out through a pretest-posttest design, administered to both experimental and control groups. This procedure allowed for the measurement of learning gains following the application of the instructional model.

The collected data were subjected to normality testing using the Kolmogorov-Smirnov test, with a significance threshold of 0.05. Datasets with p-values equal to or above 0.05 were considered to follow a normal distribution. Homogeneity of variance was tested using Bartlett's test. To evaluate the hypotheses, the study employed Multivariate Analysis of Variance (MANOVA), with all statistical analyses processed using SPSS version 22.0.

The Contextual Teaching and Learning (CTL) model served as the instructional framework for the experimental group. Its implementation adhered to seven key pedagogical components: constructivism, learning community, inquiry, questioning, modeling, reflection, and authentic assessment. These principles structured the classroom environment to foster active learning, collaborative engagement, and contextual relevance throughout the intervention phase.

RESULTS AND DISCUSSION

Results

This study aimed to examine the effectiveness of the applied learning model by comparing students' conceptual understanding and critical thinking skills between the experimental and control classes. At the end of the learning process, a test was administered comprising items that had been previously examined for validity, reliability, item difficulty, and discrimination power. From the total of 14 items tested during the trial phase, 9 were found to meet the required psychometric criteria and were thus selected for use in the actual study. These test items were then used to collect post-learning data from both groups. A summary of the students' performance on conceptual understanding and critical thinking is presented in Table 1, which displays the mean scores, standard deviations, and score ranges for both the experimental and control classes.

Table 1. Descriptive Statistics of Conceptual Understanding

Class	X_{max}	X_{min}	Measures of Central Tendency			Group Variance Measure	
			$\bar{x}$	M_o	M_e	R	Sd
Experiment	41,67	16,67	26, 94	25	25	25,00	6,770
Control	36,11	11,11	22, 87	25	23	25,00	5,956

Based on Table 1, it can be observed that students in the experimental class, who were taught using the Contextual Teaching and Learning (CTL) model with an ethnomathematics approach, achieved a higher mean score (M = 26.94) in conceptual understanding and critical thinking compared to the control class (M = 22.87). Although the mode in both classes is the same (Mo = 25), the median in the experimental class (Me = 25) is slightly higher than that of the control class (Me = 23), indicating a more symmetrical and concentrated score distribution among students. Furthermore, the experimental class shows a greater standard deviation (Sd = 6.770) than the control class (Sd = 5.956), suggesting a slightly wider dispersion of student performance within the experimental group. These results preliminarily indicate that the use of the CTL model integrated with ethnomathematics may enhance students' conceptual understanding and critical thinking more effectively than traditional instructional methods. To provide a more detailed comparison, Table 2 presents the descriptive statistics specifically for students' conceptual understanding in both the experimental and control classes.

Table 2. Descriptive Statistics of Critical Thinking

Class	X_{max}	X_{min}	Measures of Central Tendency			Group Variance Measure	
			$\bar{x}$	M_o	M_e	R	Sd
Experiment	83,33	55,56	68,88	69	25	27,78	7,83
Control	77,78	50,00	62,77	61	23	27,78	7,77

As shown in Table 2, the highest posttest score in the experimental class was 83.33, while the highest score in the control class was 77.78. The lowest score recorded in the experimental class was 55.56, compared to 50.00 in the control class. The mean score of the experimental class was 68.88, which was higher than the control class's mean of 62.77. These results indicate that the students' conceptual understanding in the experimental class, which was taught using the Contextual Teaching and Learning (CTL) model, was better than that of the control class. To evaluate the effectiveness of the instructional model, a normalized gain (N-Gain) analysis was conducted on students' conceptual understanding and critical thinking skills. The results of this analysis are presented in Table 3.

Table 3. N-Gain Test Results for Conceptual Understanding and Critical Thinking Skills

Class	Averange		N-Gain	Category
	Pretest	Posttest		
Experiment	26,94	68,89	0,68	Medium
Control	22,87	62,78	0,62	Medium

As shown in Table 4, the experimental class achieved a higher N-Gain score (0.68) than the control class (0.62), although both fall within the medium category. This suggests that the use of the Contextual Teaching and Learning (CTL) model contributed more effectively to improving students' conceptual understanding and critical thinking compared to conventional methods. To ensure that the data met the assumptions for further analysis, normality and homogeneity tests were conducted prior to hypothesis testing. The results are presented in Table 5 and Table 6.

Table 4. Normality Test Results

Class	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig
Pretest Experiment	,180	30	,015
Posttest Experiment	,138	30	,048
Pretest Control	,151	30	,080
Posttest Control	,150	30	,081

Table 5. Homogenity Test Results

	Levene statistic	df1	df2	sig
Pretest	,018	1	58	,895
Posttest	,014	1	58	,908

The normality and homogeneity test results are presented in Table 4 and Table 5. Based on the Kolmogorov–Smirnov test, only the pre-test and post-test scores of the control class were normally distributed (sig. > 0.05). Meanwhile, the scores in the experimental class did not meet the normality assumption. Despite this, homogeneity testing using Levene's test indicated that both pre-test and post-test data between the experimental and control groups were homogeneous (sig. > 0.05), suggesting that the data variances were equal across groups.

This study examines the effect of the Contextual Teaching and Learning (CTL) model on students' conceptual understanding and critical thinking through a MANOVA test. The results are presented in Table 6.

Table 6. MANOVA Test Results on Students' Conceptual Understanding and Critical Thinking

Influence		Value	F	Hypothesis df	Error df	sig
CTL Model	Pillai's Trace	.987	2099.774[b]	2.000	57.000	.000
	Wilks' Lambda	.013	2099.774[b]	2.000	57.000	.000
	Hotelling's Trace	73.676	2099.774[b]	2.000	57.000	.000
	Roy's Largest Root	73.676	2099.774[b]	2.000	57.000	.000

Table 6 presents the MANOVA results, indicating a significance value of 0.000. This result confirms that the Contextual Teaching and Learning (CTL) model has a significant overall effect on students' conceptual understanding and critical thinking. Based on this finding, the use of CTL can be considered an effective instructional approach for enhancing these cognitive skills.

Discussion

The findings of this study revealed that the implementation of the Contextual Teaching and Learning (CTL) model significantly improved students' conceptual understanding and critical thinking abilities. The increase in post-test scores and N-Gain values in the experimental class suggests that students who were exposed to CTL-based instruction demonstrated better learning outcomes compared to those in the control class. These improvements highlight the potential of CTL in fostering meaningful learning, as the model emphasizes real-world connections and student-centered activities that allow for deeper cognitive processing.

The enhancement of students' critical thinking skills in the CTL class can be attributed to the model's emphasis on inquiry, reflection, and collaborative problem-solving. CTL encourages students to question, analyze, and evaluate information rather than merely memorize procedures. Through guided discovery, group discussions, and authentic tasks, learners are given opportunities to articulate their reasoning and explore alternative strategies. This aligns with Facione's (2011) framework, which asserts that critical thinking develops through active engagement and metacognitive reflection within rich learning environments. In terms of conceptual understanding, the use of contextual problems allowed students to internalize mathematical ideas through meaningful experiences. Rather than abstract drills, learners engaged with mathematical content that was grounded in everyday situations, promoting schema development and long-term retention. The results affirm the work of Boaler (2016), who stated that context-based learning fosters conceptual clarity and motivation. Students' improved performance indicates a shift from surface learning to deeper, more connected understanding of mathematical concepts.

An additional strength of this study lies in its integration of ethnomathematics within the CTL framework. By embedding local cultural contexts in the learning process—such as traditional patterns, community practices, or culturally familiar problem settings—students were better able to relate mathematical content to their lived realities. This approach aligns with the principles of culturally relevant pedagogy and supports the findings of Rosa and Orey (2011), who emphasized that ethnomathematical integration can strengthen student identity, engagement, and reasoning skills. In this study, the use of such contexts appeared to reduce abstractness and enhance both motivation and comprehension.

These results are also consistent with prior international research. The National Council of Teachers of Mathematics (2014) has long advocated for contextualized and student-centered instruction as key to effective mathematics learning. Civil (2007) found that incorporating students' cultural experiences into mathematics instruction improves conceptual learning and promotes inclusivity. Furthermore, studies such as Lipka et al. (2005) demonstrated the positive influence of culturally relevant mathematics teaching in Indigenous and minority settings. The current findings not only align with these studies but also contribute localized evidence supporting the application of CTL combined with ethnomathematics in Indonesian classrooms.

Implication

The results of this study offer valuable implications for mathematics educators, curriculum developers, and teacher training programs. First, the integration of the CTL model into classroom practice can be a powerful strategy for promoting both conceptual understanding and critical thinking among students. Second, the inclusion of ethnomathematical contexts enhances the cultural relevance of mathematics education, making it more engaging and accessible. For teachers, this suggests the need to design learning activities that draw from students' cultural backgrounds while aligning with curriculum goals. For policymakers, these findings highlight the importance of promoting contextual and culturally responsive pedagogy as part of national education reform initiatives.

Limitation and Suggestion

This study was limited to a specific school context, a relatively small sample size, and a single mathematical topic, which may restrict the generalizability of the findings. The short duration of the intervention also prevents conclusions about long-term effects. Moreover, while the ethnomathematical approach was integrated into the CTL model, its individual impact was not examined in isolation. Future research should involve more diverse educational settings, apply the model to various mathematical topics, and consider longitudinal designs to assess lasting impacts. It is also recommended to explore the distinct contribution of ethnomathematics within CTL through mixed-method studies for a more comprehensive understanding.

CONCLUSION

The findings of this study demonstrate that the application of the Contextual Teaching and Learning (CTL) model integrated with an ethnomathematics approach significantly improves students' conceptual understanding and critical thinking skills in mathematics. Students in the experimental group, who engaged with culturally relevant contexts and were encouraged to actively construct their knowledge through CTL principles, outperformed those in the control group. These results highlight the importance of learner-centered pedagogies that connect mathematical content with students' real-life experiences and cultural backgrounds. The integration of CTL and ethnomathematics not only deepens comprehension but also fosters reflective and analytical thinking, making mathematics more meaningful and accessible. Overall, the CTL model supported by ethnomathematical contexts holds promise as an effective instructional strategy for enhancing essential 21st-century mathematical competencies.

AUTHOR CONTRIBUTION

Both authors contributed significantly to the completion of this research. The first author was primarily responsible for the development of the research design, data collection, and the initial drafting of the manuscript. The second author provided methodological guidance, conducted data validation, and offered critical revisions to enhance the clarity, coherence, and scholarly rigor of the article. Both authors reviewed and approved the final version of the manuscript.

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