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The Implementation of Problem-Based Learning to Enhance Critical Thinking Skills in Solving Contextual Mathematics Problems

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Abstract: This study aims to improve students' critical thinking skills in addressing contextual mathematical problems by implementing the Problem-Based Learning (PBL) model in Grade X at SMA Muhammadiyah 3 Surakarta. Using a classroom action research approach with two cycles, data collection included learning observations and critical thinking skills tests. The findings indicate that the implementation of the PBL model effectively enhances students' critical thinking skills in solving contextual mathematical problems. This is evidenced by an increase in students' critical thinking test scores from Cycle I to Cycle II. Furthermore, learning observations revealed improvements in students' engagement, enthusiasm, and proficiency in analyzing and solving contextual mathematics problems. This study underscores the importance for mathematics educators to integrate the PBL model into their teaching practices to enhance students' critical thinking skills. The PBL model has been proven effective in fostering student motivation, increasing participation in learning activities, and cultivating critical thinking skills.

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Introduction

Quality education is a cornerstone for cultivating competent human resources and shaping a brighter future. Investment in education empowers individuals to contribute significantly to the progress of their communities and nations (Darwati & Purana, 2021). In this context, enhancing the standards and effectiveness of educational systems is essential. The *Kurikulum Merdeka*, introduced in Indonesia, positions teachers as facilitators, enabling innovative approaches and learning models that promote successful educational processes and the development of 21st-century skills (Ati & Setiawan, 2020). These skills emphasize real-world learning experiences, allowing students to engage in tasks relevant to real-life challenges, thus aligning with the evolving demands of contemporary education.

In the 21st century, critical thinking has emerged as an indispensable skill for individuals navigating the complexities of globalization. The abundance of information in the digital era necessitates the ability to discern, evaluate, and utilize accurate and reliable data. Critical thinking involves systematic, logical, and reflective procedures to investigate and assess factual information and claims made by others (Ratih Ayu Rianti et al., 2023; Ulva, 2018). In mathematics, critical thinking transcends the pursuit of correct answers, focusing instead on understanding the underlying processes and principles (Anugraheni, 2019). This skill fosters analytical reasoning and equips students to tackle complex problems. One effective strategy to develop critical thinking is through contextual mathematical problems—

problems that relate to real-life scenarios. These problems challenge students with higher complexity compared to abstract mathematical problems, requiring a deep understanding of mathematical principles and their practical applications (Masdy, 2021). Engaging with such problems enables students to comprehend how mathematical concepts operate in real-world settings, thereby cultivating critical, creative, and innovative thinking.

Critical thinking comprises four key indicators: (1) interpretation, involving the comprehension of problems through relevant information synthesis; (2) analysis, identifying relationships among statements, questions, and concepts while constructing accurate mathematical models; (3) evaluation, ensuring precise problem resolution; and (4) inference, drawing conclusions from the analyzed problem (Andriani & Suparman, 2018). Mathematics education plays a pivotal role in enhancing students' critical thinking skills within its domain (Fauziah & Fitria, 2022). An instructional approach known as Problem-Based Learning (PBL) has shown promise in fostering critical thinking. PBL is a student-centred model that introduces contextual problems aligned with real-life situations. By actively engaging in the resolution of authentic mathematical challenges, students sharpen their critical thinking abilities (Pransisca et al., 2023). The PBL process involves sequential steps: (1) presenting a problem, (2) facilitating student-led learning activities, (3) guiding individual and group investigations, (4) supporting students in developing and presenting findings, and (5) analyzing and evaluating problem-solving processes (Rosidah, 2018).

Preliminary observations and pre-tests conducted in Class X-1 at SMA Muhammadiyah 3 Surakarta revealed low levels of critical thinking among students. Addressing this issue is vital to ensure quality learning outcomes. Therefore, this study aims to implement the Problem-Based Learning (PBL) model, utilizing student worksheets (LKPD) with contextual problems to improve students' critical thinking skills. By centring the learning process on students and fostering active engagement in problem-solving tasks, PBL offers a robust framework to enhance critical thinking, contributing both theoretically and practically to the advancement of mathematics education.

Research Method

This study employs a Classroom Action Research (CAR) design with a quantitative descriptive approach. The primary aim is to enhance students' critical thinking skills through the implementation of a Problem-Based Learning (PBL) model focused on arithmetic sequences and series. The research was conducted in October 2023, involving 20 tenth-grade students (Class X-1) from SMA Muhammadiyah 3 Surakarta, comprising 8 male and 12 female students.

Instruments

The instrument used to assess students' critical thinking skills in each cycle consisted of contextual problem-solving questions designed based on the PBL model. These questions focused on arithmetic sequences and series. Students' performance on a post-test conducted at the end of each cycle served as the primary data source for evaluating critical thinking skills.

Data Collection Procedures

The study was carried out over two cycles, with each cycle comprising two sessions, each lasting 2×45 minutes. The steps of the research were as follows (1) problem Identification. The researcher identified the challenges faced by students in learning arithmetic sequences and series through interviews with the Class X-1 teacher. Based on this analysis, post-test instruments were developed; (2) implementation Phase. The students were introduced to the concepts of arithmetic sequences and series, followed by group work on worksheets (LKPD) designed using the PBL approach. Individual post-tests were then

administered to measure learning outcomes and critical thinking improvement; (3) evaluation Phase. Post-test results were collected, analyzed, and revised as needed.

Data Analysis

Data were analyzed using a quantitative descriptive approach. The formula below was used to determine the success rate of the PBL-based LKPD implementation:

$$P = \frac{x}{y} \times 100\%$$

Note:

P = Percentage of students achieving mastery

x = Number of students scoring above the minimum passing grade (KKM)

y = Total number of students

Criteria for Critical Thinking

Students' critical thinking abilities were categorized based on their post-test scores, as shown in Table 1.

Table 1. Critical Thinking Criteria

Score Range	Critical Thinking Criteria
76–100	High
51–75	Medium
0–50	Low

Implementation Timeline

The study spanned two cycles, each comprising two meetings. The interventions included instructional sessions on arithmetic sequences and series, group discussions facilitated by PBL-based worksheets, and individual post-tests.

Result and Discussion

This study employed Kurt Lewin's action research model, consisting of four key stages: planning, action, observation, and reflection (Slameto, 2015). During the planning stage, the researcher designed the study and prepared the instructional model and tools to be used, including student worksheets (LKPD) based on Problem-Based Learning (PBL) contextual problems and post-tests for each cycle. The primary focus of the research was to enhance students' critical thinking skills, which included interpreting, analyzing, evaluating, and inferring information. Students were presented with post-test questions comprising contextual problems, which they were required to solve independently to evaluate their critical thinking skills.

Critical Thinking Development Across Cycles

In Cycle 1, students were provided with pre-test problems completed individually to assess their baseline critical thinking skills before implementing the PBL model. The minimum passing criterion (Kriteria Ketuntasan Minimal, KKM) for the mathematics subject of Grade X-1 at SMA Muhammadiyah 3 Surakarta was 75.

The results presented in Table 2 highlight a significant improvement in students' critical thinking skills across three learning cycles: Pre-Cycle, Cycle 1, and Cycle 2. Four key indicators were observed: interpretation, analysis, evaluation, and inference, with a minimum passing standard (KKM) of 75. In the Pre-Cycle, the average class score was 56.6, indicating low critical thinking skills, with only 37.5% of students meeting the KKM. Improvements

began to emerge in Cycle 1, where the average class score increased to 75.1, with 56.25% of students achieving the KKM. Cycle 2 showed more promising results, with the average class score rising to 83.9 and classical mastery reaching 81.25%.

Table 2. Illustrates the progression of critical thinking skills across different indicators and cycles.

Indicator	KKM	Total Students	Pre-Cycle Completion (Average Score)	Cycle 1 Completion (Average Score)	Cycle 2 Completion (Average Score)
Interpretation	75	20	10 (70)	14 (81)	18 (88)
Analysis	75	20	8 (62)	13 (77)	17 (85)
Evaluation	75	20	7 (54.5)	10 (72.5)	15 (82)
Inference	75	20	5 (40)	8 (70)	14 (80.75)
Average Score			56.6	75.1	83.9
Classical Mastery			37.5%	56.25%	81.25%

Each indicator demonstrated consistent progress from the Pre-Cycle to Cycle 2. The interpretation indicator had the highest scores, improving from 70 in the Pre-Cycle to 88 in Cycle 2, reflecting an increase in students' ability to comprehend and interpret information. Meanwhile, the inference indicator, which had the lowest initial score (40), showed the most substantial improvement, reaching 80.75 in Cycle 2. The evaluation and analysis indicators also recorded significant gains, increasing from 54.5 and 62 in the Pre-Cycle to 82 and 85 in Cycle 2, respectively, indicating enhanced abilities in assessing information and analyzing complex problems.

During the pre-cycle phase, the learning activities were traditional, teacher-centered, and relied heavily on lectures. Students exhibited passivity and dependence on the teacher when solving problems. This issue was addressed in Cycle 1 by introducing the PBL model with LKPD to encourage active participation and collaboration. In Cycle 1, the students engaged in group discussions to identify and explore the concepts of the material. However, challenges were observed, including a lack of focus and hesitancy to express opinions. To address these limitations, Cycle 2 introduced multimedia aids, such as video-based problem presentations accessed via QR codes, and motivational strategies to boost students' confidence in articulating their thoughts.

Data collection during the research highlighted the effectiveness of PBL across its structured phases, including problem orientation, group collaboration, and independent investigation. Students were tasked with analyzing problems, identifying critical information, and formulating pertinent questions. Through iterative presentations and evaluations, students developed problem-solving strategies, evaluated alternatives, and chose optimal solutions. These activities aligned with findings from Kiswanto (2017), emphasizing the role of discussions, arguments, and reflections in fostering critical thinking. The systematic problem-solving process in PBL, characterized by identifying knowns, posing questions, and selecting strategies, significantly enhanced students' comprehension of contextual problems. PBL also encouraged interaction, facilitated concept discovery, and improved problem-solving techniques, confirming its effectiveness in nurturing critical thinking skills. As Sitompul (2021) observed, mathematical contexts in PBL strengthen cognitive abilities by addressing real-world issues, promoting conceptual understanding, and preparing students to solve complex problems.

This study aligns with previous findings, such as Wahyudiyantoro et al. (2023), who demonstrated improved critical thinking skills through PBL implementation in elementary school mathematics classes. Similarly, Aisyah et al. (2023) highlighted the efficacy of PBL worksheets in enhancing critical thinking among junior high school students. Overall, the data demonstrate that the learning strategies implemented during the study successfully improved students' critical thinking skills. This success is evident from the increased average scores across all indicators and the rise in classical mastery percentages in each cycle. These findings suggest that problem-based learning or group discussions, likely employed during the intervention, can be applied more broadly to foster the development of critical thinking skills. However, particular attention should still be given to the inference indicator, which started with the lowest initial score, to ensure continued improvement in this area.

Conclusion

The findings of this Classroom Action Research (CAR) demonstrate the effectiveness of the Problem-Based Learning (PBL) model in improving critical thinking skills in contextual mathematical problem-solving among Grade X-1 students at SMA Muhammadiyah 3 Surakarta. The average score increased from 56.6 in the pre-cycle to 75.1 in Cycle 1 and further to 83.9 in Cycle 2, while classical mastery rose from 37.5% to 81.25%. This improvement underscores the transformative potential of PBL in fostering critical thinking. The integration of PBL enabled educators to unlock students' latent potential and equip them with skills essential for future success. Critical thinking enhancement benefits students not only academically but also in broader life applications. By fostering an environment that encourages analytical problem-solving and exploration of diverse perspectives, PBL empowers students to develop a comprehensive spectrum of cognitive skills.

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