Enhancing Students' Critical Thinking Skills through Cooperative Problem Posing in Mathematics Learning: A Classroom Action Research

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Abstract

This study aims to enhance students' critical thinking skills in mathematics through the implementation of a problem posing approach within a cooperative learning setting. The research employed Classroom Action Research (CAR) using a qualitative–quantitative approach, conducted in a Grade VIII class at SMP Negeri 2 Kota Pasuruan. The research was carried out in two cycles, each consisting of planning, action, observation, and reflection stages. Data were collected using critical thinking tests, learning activity observation sheets, field notes, and interviews. Quantitative data were analysed descriptively, while qualitative data were analysed thematically and triangulated to ensure credibility. The results show a significant improvement in students' critical thinking skills from Cycle I to Cycle II. The percentage of students achieving the minimum mastery criterion increased from 44.12% to 61.76%, accompanied by notable improvement in students' ability to analyse mathematical statements and engage in cooperative discussions. In addition, the implementation of learning activities reached a very high category in Cycle II, indicating improved instructional effectiveness. These findings suggest that integrating problem posing into cooperative learning creates an active and reflective learning environment that supports the development of critical thinking skills in mathematics. Therefore, this approach is recommended as an alternative instructional strategy for secondary mathematics education.

Abstrak

Penelitian ini bertujuan untuk meningkatkan kemampuan berpikir kritis siswa dalam pembelajaran matematika melalui penerapan pendekatan problem posing dalam setting pembelajaran kooperatif. Penelitian ini menggunakan Penelitian Tindakan Kelas (PTK) dengan pendekatan kualitatif–kuantitatif yang dilaksanakan pada siswa kelas VIII SMP Negeri 2 Kota Pasuruan. Penelitian dilakukan dalam dua siklus yang masing-masing meliputi tahap perencanaan, pelaksanaan tindakan, observasi, dan refleksi. Data dikumpulkan melalui tes kemampuan berpikir kritis, lembar observasi aktivitas pembelajaran, catatan lapangan, dan wawancara. Data kuantitatif dianalisis secara deskriptif, sedangkan data kualitatif dianalisis secara tematik dan ditriangulasi untuk meningkatkan

keabsahan data. Hasil penelitian menunjukkan adanya peningkatan kemampuan berpikir kritis siswa dari Siklus I ke Siklus II. Persentase siswa yang mencapai ketuntasan belajar meningkat dari 44,12% menjadi 61,76%, disertai peningkatan kemampuan siswa dalam menganalisis pernyataan matematis dan berpartisipasi aktif dalam diskusi kelompok. Selain itu, keterlaksanaan pembelajaran pada Siklus II mencapai kategori sangat tinggi. Temuan ini menunjukkan bahwa integrasi problem posing dalam pembelajaran kooperatif mampu menciptakan lingkungan belajar yang aktif dan reflektif serta mendukung pengembangan kemampuan berpikir kritis siswa dalam matematika.

A. INTRODUCTION

Mathematics learning at the junior secondary school level plays a crucial role in developing students' critical thinking skills, particularly in preparing them to solve non-routine problems and justify mathematical reasoning. Theoretically, critical thinking in mathematics refers to students' ability to analyse problem situations, evaluate solution strategies, and draw logical conclusions based on mathematical evidence (Facione, 2015). Constructivist learning theory emphasises that these abilities emerge when students are actively involved in constructing knowledge through exploration, reflection, and interaction. However, the realisation of these theoretical ideals in classroom practice often remains problematic.

This condition is clearly observed in SMP Negeri 2 Kota Pasuruan, the setting of the present study. Based on preliminary classroom observations and initial assessments conducted by the researcher, mathematics learning in this school is still largely dominated by teacher-centred instruction. Students are generally accustomed to receiving explanations, following worked examples, and completing routine exercises. When presented with problems that require interpretation, reasoning, or justification, many students experience difficulties in articulating their thinking and tend to wait for direct guidance from the teacher. This indicates that students' critical thinking skills have not been optimally developed within the existing instructional practices.

The gap between theoretical expectations and classroom reality becomes increasingly evident when considering contemporary educational demands. International educational frameworks emphasise critical thinking as a key competency for twenty-first-century learners, particularly in mathematics and science education (OECD, 2019; OECD, 2023). Nevertheless, in classroom realities such as those found at SMP Negeri 2 Kota Pasuruan, learning activities that explicitly train students to question, analyse, and evaluate mathematical ideas remain limited. Instructional success is often measured by students' ability to obtain correct answers rather than by the quality of their reasoning processes.

From a pedagogical perspective, learning activities that promote higher-order thinking should place students at the centre of the learning process. According to Chi and Wylie's (2014) ICAP framework, students achieve deeper learning when they are

engaged at constructive and interactive levels. However, observations at SMP Negeri 2 Kota Pasuruan indicate that most learning activities remain at passive or merely active levels, such as listening to explanations or applying formulas in routine tasks. This learning pattern restricts students' opportunities to develop critical thinking through exploration and reflection.

One instructional approach that aligns well with the theoretical need to foster critical thinking is problem posing. Problem posing requires students to generate or modify mathematical problems, thereby encouraging them to analyse mathematical relationships and reflect on conceptual structures. Silver (2019) argues that problem posing can function as a powerful cognitive activity that promotes critical and creative thinking in mathematics learning. Empirical studies also report that students who engage in problem posing demonstrate improved reasoning and conceptual understanding (Leung & Silver, 2021).

However, research also shows that problem posing is not automatically effective when implemented in traditional classroom settings. Cai et al. (2020) note that students often struggle to pose meaningful problems when they are not accustomed to open-ended tasks or reflective thinking. This challenge is particularly relevant in classrooms like those at SMP Negeri 2 Kota Pasuruan, where students have long been exposed to teacher-directed instruction. Without adequate support and interaction, problem posing activities may result in superficial questions rather than deep analytical thinking.

To address this limitation, cooperative learning provides a pedagogical framework that can support the effective implementation of problem posing. Cooperative learning is grounded in social constructivist theory, which emphasises learning as a social process mediated by interaction and dialogue (Voogt et al., 2018). Through structured group activities, students can exchange ideas, challenge each other's reasoning, and refine their understanding collaboratively. Freeman et al. (2014) demonstrate that cooperative learning significantly enhances students' higher-order thinking skills compared to individual learning approaches.

Integrating problem posing into a cooperative learning environment offers a promising solution to the instructional challenges observed at SMP Negeri 2 Kota Pasuruan. In cooperative problem posing activities, students are encouraged not only to generate problems but also to discuss, evaluate, and revise them collectively. This process allows students to externalise their thinking, receive immediate feedback from peers, and engage in reflective dialogue, all of which are essential for developing critical thinking skills (Rezat & Straesser, 2019).

Despite the strong theoretical rationale, studies that explicitly examine the integration of problem posing and cooperative learning in junior secondary mathematics classrooms remain limited. Existing research often investigates problem posing or cooperative learning separately, with a primary focus on learning outcomes rather than on the development of critical thinking processes. Moreover, research conducted in authentic classroom settings, particularly using classroom action research designs, is still relatively scarce (Falloon, 2020). This gap is especially relevant

for SMP Negeri 2 Kota Pasuruan, where instructional improvement must be grounded in real classroom conditions.

Therefore, this study aims to implement cooperative problem posing as an instructional strategy to enhance students' critical thinking skills in mathematics learning at SMP Negeri 2 Kota Pasuruan. By employing a classroom action research approach, this study seeks to systematically improve learning practices through iterative cycles of planning, action, observation, and reflection. The novelty of this study lies in its contextualised focus on the integration of problem posing and cooperative learning to address empirically identified classroom problems, rather than merely testing theoretical assumptions.

Through this approach, the study is expected to contribute both theoretically and practically. Theoretically, it strengthens the understanding of how cooperative problem posing supports the development of critical thinking in mathematics. Practically, it provides teachers at SMP Negeri 2 Kota Pasuruan and similar educational contexts with a concrete instructional model that is responsive to contemporary educational demands and grounded in classroom realities.

B. METHOD

This study employed Classroom Action Research (CAR) with a qualitative–quantitative approach. The CAR design was selected to address empirically identified instructional problems and to improve mathematics learning practices in an authentic classroom setting. The research followed a cyclical model consisting of planning, action, observation, and reflection, allowing systematic improvement of instructional strategies across cycles. This design was considered appropriate because the primary objective of the study was not merely to test an intervention, but to enhance students' critical thinking skills through iterative instructional refinement.

Research Setting and Participants

The study was conducted at SMP Negeri 2 Kota Pasuruan, East Java, Indonesia. The participants were students of Grade VIII, selected through purposive sampling based on their involvement in mathematics learning during the academic year of the study. The class was chosen due to identified learning challenges related to low student participation and limited critical thinking skills in mathematics. The mathematics teacher of the class collaborated with the researcher throughout the research process to ensure the natural implementation of instructional activities.

Research Procedure

The research was carried out in two cycles, with each cycle consisting of four stages:

1. Planning, which involved designing lesson plans based on cooperative learning integrated with problem posing, preparing learning materials, observation instruments, and assessment tools.
2. Action, during which the learning activities were implemented in the classroom. Students worked in small cooperative groups to generate, discuss, and refine mathematical problems based on the given learning material.

3. Observation, where students' learning activities and critical thinking behaviours were systematically observed and recorded using structured observation sheets.
4. Reflection, in which the results of each cycle were analysed to identify strengths and weaknesses of the instructional implementation, serving as the basis for improving the subsequent cycle.

Instructional Intervention

The instructional intervention focused on cooperative problem posing in mathematics learning. Students were organised into heterogeneous groups and engaged in activities that required them to formulate mathematical problems, exchange ideas, and evaluate the validity of posed problems collaboratively. The teacher acted as a facilitator, guiding discussion and providing scaffolding when necessary. This learning design was intended to promote students' analytical, evaluative, and reflective thinking processes, which are central to critical thinking.

Research Instruments

Data were collected using three main instruments:

1. Critical Thinking Skills Test, designed to measure students' ability to analyse problems, justify reasoning, and draw logical conclusions in mathematics.
2. Learning Activity Observation Sheet, used to capture students' cognitive, verbal, and collaborative engagement during cooperative problem posing activities.
3. Field Notes and Reflection Sheets, used to document classroom dynamics, student responses, and instructional challenges during each cycle.

All instruments were reviewed by subject-matter experts to ensure content validity and clarity. Revisions were made based on expert feedback prior to implementation.

Data Collection and Analysis

Data collection was conducted throughout the instructional cycles. Quantitative data from critical thinking tests were analysed using descriptive statistics to identify improvements across cycles. Qualitative data from observation sheets and field notes were analysed using thematic analysis to capture patterns in students' learning activities and critical thinking behaviours. The results from both data sources were triangulated to enhance the credibility and trustworthiness of the findings.

The criteria of success for this study were defined as:

1. An increase in students' critical thinking scores across cycles, and
2. Improvement in students' learning activity levels, particularly in analytical discussion, problem formulation, and justification of ideas.

The research was considered successful when the majority of students demonstrated meaningful improvement in both critical thinking skills and active participation in mathematics learning.

C. RESULT

Research Implementation Overview

This classroom action research was conducted in Grade XI Science 1 of SMA Negeri 1 Sewon over two cycles during November 2025. Each cycle consisted of three meetings, including two instructional sessions and one evaluation session. The intervention implemented a problem posing approach within a cooperative learning setting, focusing on enhancing students' critical thinking skills in circle equation topics.

The instructional activities across both cycles covered progressively complex concepts, beginning with circle equations centred at the origin and extending to general forms of circle equations as well as the position of points and lines relative to a circle. Table 1 summarises the implementation of the research across cycles.

Table 1. Overview of Classroom Action Research Implementation

Cycle	Meeting	Main Learning Activities
I	1–2	Circle equations centred at (0,0) and (a,b) using problem posing in cooperative groups
I	3	Critical thinking ability test (Cycle I)
II	1–2	General form of circle equations and position of points and lines
II	3	Critical thinking ability test (Cycle II)

Results of Cycle I

Students' Critical Thinking Ability in Cycle I

Students' critical thinking ability was measured at the end of Cycle I using an essay-based test consisting of five items. Students were considered to achieve mastery if they reached the minimum mastery criterion (KKM) of 75. The results indicate that only 15 out of 34 students achieved mastery, representing 44.12% of the class. This percentage did not meet the success indicator of at least 60% mastery, indicating that further instructional improvement was required.

Table 2. Critical Thinking Test Results in Cycle I

Indicator of Critical Thinking	Percentage
Understanding the problem	84.12%
Identifying errors in mathematical problems	79.94%
Analysing mathematical statements	51.18%
Applying concepts to new problems	62.35%
Average	66.59%

The data show that students performed well in understanding problems and identifying errors. However, lower achievement was observed in analysing statements and applying concepts to new situations, indicating limited higher-order critical thinking performance during Cycle I.

Implementation of Learning Activities in Cycle I

The observation of learning implementation was conducted during two instructional meetings using an observation checklist aligned with the lesson plan. The results indicate that the learning activities were generally implemented at a high level.

Table 3. Learning Implementation in Cycle I

Meeting	Percentage	Category
Meeting 1	80%	High
Meeting 2	85%	Very High
Average	**82.5%**	**Very High**

Although the overall implementation was categorised as very high, several learning activities were not optimally conducted, particularly students' responses to peer presentations and the completion of all worksheet exercises within class time.

Reflection on Cycle I

Reflection on Cycle I revealed several challenges, including suboptimal group discussions, students' dependence on teacher assistance, limited quality of student-generated problems, and insufficient time management during worksheet completion. These findings informed the revision of instructional strategies in Cycle II.

Results of Cycle II

Students' Critical Thinking Ability in Cycle II

Following improvements in instructional implementation, students' critical thinking ability was reassessed at the end of Cycle II using a six-item essay test. The results demonstrate a notable improvement compared to Cycle I. A total of 21 students achieved mastery, corresponding to 61.76% of the class, exceeding the predefined success criterion.

Table 4. Critical Thinking Test Results in Cycle II

Indicator of Critical Thinking	Percentage
Understanding the problem	79.02%
Identifying errors in mathematical problems	66.18%
Analysing mathematical statements	84.41%
Applying concepts to new problems	63.82%
Average	72.25%

The data indicate substantial improvement in students' ability to analyse mathematical statements, suggesting that the revised learning design more effectively supported higher-order thinking processes.

Implementation of Learning Activities in Cycle II

Observational data show a significant improvement in the implementation of learning activities during Cycle II.

Table 5. Learning Implementation in Cycle II

Meeting	Percentage	Category
Meeting 1	90%	Very High
Meeting 2	100%	Very High
Average	95%	Very High

The results indicate that all instructional steps were implemented optimally, with increased student participation, improved group collaboration, and effective classroom management.

Interview Results

Interviews conducted with students and the mathematics teacher at the end of Cycle II revealed positive perceptions of the learning process. Students reported higher engagement, deeper conceptual understanding, and increased confidence in solving mathematical problems. The teacher observed improved student participation and more meaningful classroom interactions.

Overall, the results demonstrate a consistent improvement from Cycle I to Cycle II in terms of students' critical thinking ability and the quality of learning implementation. The percentage of students achieving mastery increased from 44.12% to 61.76%, while the implementation of problem posing with a cooperative setting reached a very high category. These findings indicate that the applied instructional approach effectively enhanced students' critical thinking performance in mathematics learning.

D. DISCUSSION

The findings of this classroom action research demonstrate that the implementation of a problem posing approach within a cooperative learning setting contributes meaningfully to the development of students' critical thinking skills in mathematics learning, particularly in the topic of circle equations. The gradual improvement observed from Cycle I to Cycle II indicates that critical thinking does not emerge instantaneously but develops through sustained exposure to cognitively demanding learning activities. This finding is consistent with constructivist learning theory, which views learning as an active process in which students construct knowledge through exploration, reflection, and social interaction (Ernest, 2018).

Problem posing positions students not merely as problem solvers but as problem generators, requiring them to analyse mathematical concepts, evaluate relationships among variables, and apply concepts in novel situations. According to Silver (2017), the act of generating problems engages higher-order thinking processes because students must first understand the structure of a concept before transforming it into a meaningful mathematical question. This theoretical perspective explains why, in Cycle I, students initially struggled to formulate varied and solvable problems, particularly when they were unfamiliar with learning environments that demanded autonomy and creativity. However, as instructional scaffolding was refined in Cycle II, students demonstrated substantial improvement in analysing mathematical statements and applying concepts, indicating a deeper level of cognitive engagement.

The cooperative learning setting played a critical role in supporting the effectiveness of the problem posing approach. Learning within small, heterogeneous groups enabled students to exchange ideas, clarify misconceptions, and negotiate meaning through discussion. Social constructivist perspectives emphasise that knowledge construction is enhanced when learners interact and articulate their thinking processes (Vygotsky, as discussed in Sullivan et al., 2020). The improved quality of group discussions in Cycle II suggests that cooperative structures reduced

students' reliance on teacher explanations and encouraged peer-assisted learning, which in turn fostered greater independence and reflective thinking.

Observational data further indicate that improvements in students' critical thinking were closely related to the quality of learning implementation. The increase in learning implementation from a high category in Cycle I to a very high category in Cycle II highlights the importance of instructional facilitation in student-centred learning environments. As noted by Hmelo-Silver et al. (2019), inquiry-oriented approaches such as problem posing require explicit guidance, especially in the early stages, to prevent cognitive overload and superficial engagement. The provision of clear criteria for problem construction, continuous monitoring of group activities, and timely feedback in Cycle II ensured that students remained focused on meaningful learning tasks.

From a contemporary mathematics education perspective, the results of this study align with current calls for instructional practices that prioritise higher-order thinking skills over procedural fluency alone. Large-scale assessments consistently show that students perform better on routine tasks than on problems requiring reasoning and conceptual understanding (OECD, 2019; OECD, 2023). The findings of this study suggest that problem posing, when integrated with cooperative learning, offers a practical instructional model to address this gap by encouraging students to think critically, creatively, and reflectively about mathematical concepts.

Furthermore, the use of classroom action research as the methodological framework proved effective in facilitating instructional improvement. The reflective cycle enabled the identification of concrete classroom challenges and the implementation of targeted revisions in subsequent cycles. According to McNiff and Whitehead (2018), action research empowers teachers to become reflective practitioners who continuously refine their instructional strategies based on empirical classroom evidence. The achievement of the predefined success indicators in Cycle II confirms that systematic reflection and iterative improvement are essential for successful pedagogical innovation.

Overall, this study reinforces the argument that improving students' critical thinking skills requires not only innovative instructional approaches but also carefully designed learning environments that promote active participation and meaningful interaction. Problem posing within a cooperative setting transforms mathematics learning from a teacher-dominated activity into a collaborative and inquiry-driven process. When supported by effective facilitation and reflective practice, this approach has the potential to significantly enhance students' critical thinking abilities and learning outcomes in mathematics education.

E. CONCLUSION

This classroom action research demonstrates that the implementation of a problem posing approach within a cooperative learning setting effectively enhances students' critical thinking skills in mathematics, particularly on circle-related topics. The improvement observed from Cycle I to Cycle II indicates that students' critical

thinking develops progressively when they are actively involved in generating, analysing, and solving mathematical problems. The increase in the proportion of students achieving the minimum mastery criterion, alongside the improvement in critical thinking indicators, confirms that problem posing shifts learning from procedural practice toward deeper conceptual understanding and reasoning.

Furthermore, the findings highlight that the success of the problem posing approach is strongly influenced by the quality of instructional implementation and learning facilitation. Structured group collaboration, clear guidance in problem formulation, and continuous teacher scaffolding were key factors in improving learning effectiveness. This study concludes that problem posing with a cooperative setting is not only pedagogically feasible but also highly relevant for contemporary mathematics instruction, as it fosters active learning, critical thinking, and meaningful student engagement. Therefore, this approach can be recommended as an alternative instructional strategy to support the development of higher-order thinking skills in secondary mathematics classrooms.

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