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The Influence of the Creative Problem Solving Model on Sixth-Grade Students' Critical Thinking Skills

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Abstract

In the era of rapid technological advancement and global interconnectedness, the ability to think critically has become a cornerstone of 21st-century education. Students are now required not only to absorb information but also to evaluate its relevance, analyze complex situations, and formulate well-reasoned solutions. Consequently, educators are challenged to adopt learning models that foster higher-order thinking skills and prepare students to navigate an increasingly dynamic and information-dense environment. This study investigates the influence of the Creative Problem Solving (CPS) learning model on the critical thinking skills of sixth-grade students at MI Assa'adatuddarain 1 Pamulang. Employing a quasi-experimental method with a Control Group Post-Test Only design, the research utilized cluster sampling to select participants. The instrument used was a critical thinking test consisting of six essay-type questions aligned with Ennis' indicators, as adapted from the framework used in Masani et al.'s study. The test focused on the topic of speed in the science curriculum. The findings revealed that students in the experimental group, who were taught using the CPS model, achieved an average critical thinking score of 84.07. In contrast, the control group scored an average of 72.80. The Independent Sample T-Test showed a significance value of 0.000 (<0.05), leading to the rejection of H0 and the acceptance of H1. These findings confirm that the CPS learning model has a significant positive effect on students' critical thinking skills. The implications of this study indicate that CPS can be applied as a structured instructional strategy in sixth-grade science learning, especially on topics such as speed that require students to analyze information, select appropriate problem-solving strategies, and justify their answers logically. This model helps teachers design learning activities that move students beyond memorizing formulas toward contextual reasoning and critical decision-making.

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Introduction

Critical thinking skills are a fundamental competency that students must master in facing the challenges of 21st century learning, as they enable them to carefully sort information, assess the validity of arguments, and make decisions based on logical reasoning (Jahiri et al., 2024). In an era marked by the flood of information, the acceleration of digital technology, and the complexity of social, economic, and environmental problems, students are required to not just memorize, but to understand, analyze, evaluate, and solve problems reflectively (Kontorovich, 2023). Critical thinking is also included in the 21st century skills indicators formulated in various international frameworks such as the Assessment and Teaching of 21st Century Skills (ATC21S) and is an important focus in mathematics learning because it requires the ability to provide justification, assess evidence, and connect concepts meaningfully. Educational research also shows that critical thinking is the main goal of the Indonesian education system, because through this ability students can process information, compare ideas, criticize arguments, and make decisions reflexively so that they are able to adapt to the dynamics of technological developments and global challenges in the future (R. D. Rahmawati et al., 2025). This competency is also relevant to Indonesia's long-term development agenda, because the Republic of Indonesia Law Number 59 of 2024 concerning long-term development plans emphasizes the importance of preparing superior and competitive human resources to support the realization of Indonesia Emas 2045 (UndUndang Republik Indonesia Nomor 59 Tahun 2024). Therefore, strengthening critical thinking skills since elementary school is an urgent need to form students who are independent, adaptive, and able to face real problems in the surrounding environment more rationally and responsibly.

At the elementary school level, the development of critical thinking skills becomes increasingly important because this phase is the period of forming the foundation of long-term thinking (Herianingtyas et al., 2024; Suryaningsih, 2025). Elementary school students are at a stage of cognitive development that is highly responsive to stimulation, so they need to be trained to not only memorize, but also understand concepts, ask questions, give reasons, and consider various possibilities in problem solving (Nowariak & Roehrig, 2025; Puger et al., 2024; Thornhill-Miller et al., 2023; Zakiya, 2026). Learning that focuses only on procedures and single answers tends to hinder the development of critical thinking skills, so that students have difficulty understanding concepts in depth and are less prepared to face learning challenges at the next level (Muharram et al., 2025). Therefore, strengthening critical thinking skills in elementary school students is not only a pedagogical need, but also a demand of the times so that they have cognitive readiness to adapt to technological developments, information complexity, and the demands of problem solving in real life.

The latest PISA 2022 report shows a significant decline in Indonesia's mathematics literacy performance, dropping to 366 points, a sharp decrease from the 2018 cycle and substantially below the OECD average, reflecting global post-pandemic learning loss trends (OECD, 2023). Beyond general mathematics proficiency, Indonesia also scored only 19 out of 60 on mathematics creative-thinking indicators well under the OECD average of 33 highlighting systemic weaknesses in higher-order thinking competencies such as idea generation, reasoning flexibility, and critical evaluation among Indonesian adolescents.

These findings align with broader bibliometric and meta-analytic evidence demonstrating that critical thinking research in Indonesian mathematics education remains concentrated on higher levels of schooling, while elementary-level interventions are limited and unevenly distributed. Furthermore, systematic reviews emphasize that effective enhancement of students' critical thinking requires not only curriculum strengthening but also the adoption of inquiry-oriented and problem-based pedagogies, as these methods consistently show strong positive effects on critical-thinking outcomes in mathematics (Mariani et al., 2025; Safiah et al., 2025) . Taken together, these national and international findings reveal an urgent need for learning models that explicitly cultivate structured reasoning, evaluation, and decision-making—cognitive skills increasingly central to 21st-century educational demands (Trisnani et al., 2024a).

At the primary-school level, a national qualitative study involving 114 elementary mathematics teachers from ten provinces revealed that the major barriers to integrating critical-thinking instruction include limited instructional time and resources (71.34%), insufficient pedagogical knowledge, low teacher confidence, and skepticism regarding students' ability to engage in higher-order reasoning (Trisnani et al., 2024b). These structural and pedagogical constraints often cause classroom learning to remain teacher-centered, procedural, and focused on content coverage rather than cognitive development an issue corroborated by recent classroom-interaction studies showing that explorative student discourse (asking questions, constructing arguments, clarifying ideas) rarely emerges without explicit scaffolding or collaborative problem-solving structures (Anyu, 2024; Dwiprabowo et al., 2024; Isrokatun et al., 2024). Additional reviews of Indonesian CT research also stress that teachers frequently lack access to validated assessment tools aligned with critical-thinking frameworks, hindering their ability to evaluate and support students' reasoning development (Dermawan et al., 2025; Mariani et al., 2025; Orhan, 2023). Globally, similar problems have been documented, as systematic reviews and qualitative studies in early-years education show that teachers often struggle to define critical thinking clearly and translate it into age-appropriate classroom practices and assessment (O'Reilly et al., 2022; Pollarolo et al., 2023). International evidence from PISA 2022 also shows that students' performance in open-ended creative-thinking tasks varies across school systems, reinforcing the importance of classroom environments that value idea generation, alternative solutions, and evaluation of ideas (OECD, 2024). Consequently, these challenges create a substantial gap between policy expectations and classroom implementation, underscoring the need for structured pedagogical models such as Creative Problem Solving (CPS), inquiry-based learning, or cooperative learning that can operationalize the cultivation of critical thinking in an accessible, scalable, and context-appropriate manner for elementary mathematics instruction.

The initial observation conducted in July 2024 on mathematics learning at MI Assa'adatuddarain 1 Pamulang revealed several pedagogical issues that contributed to students' low critical thinking skills. The instructional process was dominated by teacher-centered lecturing, where explanations and examples were delivered in a one-way manner without sufficient opportunities for student inquiry or exploration. Most of the problems presented to students followed repetitive patterns, limiting their exposure to varied representations and non-routine tasks that are essential for stimulating analytical reasoning. As a result, students tended to imitate the procedural steps demonstrated by the teacher rather than constructing their own understanding of the underlying mathematical concepts. This procedural dependency created difficulties when students were presented with problems that required conceptual transfer, unit conversion, or flexible strategy selection skills that are central to critical thinking in mathematics.

Furthermore, the observation indicated that no systematic or formal assessment of students' critical thinking skills had been conducted previously. Teachers relied primarily on traditional achievement tests that measure procedural accuracy rather than indicators of higher-order thinking such as clarification, justification, inference, and evaluation. Consequently, the school lacked diagnostic data to map students' cognitive profiles or to identify areas requiring targeted intervention. This aligns with broader national findings showing that many elementary teachers face challenges in integrating and assessing critical thinking due to limited pedagogical knowledge, insufficient training, and lack of appropriate assessment instruments (Lv et al., 2025; Nowariak & Roehrig, 2025; Park & Nam, 2024). Without a structured mechanism to monitor students' reasoning abilities, instructional practices tend to remain focused on content delivery rather than cognitive development.

One of the solutions that can be used to improve the quality of students' thinking processes, especially in the context of 21st century learning, is the application of the CPS model. CPS is a learning model that emphasizes students' ability to identify problems, come up with alternative solutions, choose the best strategies, and evaluate the outcome of the solution reflectively (Treffinger, 1995, 2007). This model is designed to encourage students to think creatively as well as analytically, because each stage from clarifying problems, finding ideas, developing solutions, to implementation requires students to be actively involved in the high-level reasoning process (Heidorn & Hokanson, 2025). The CPS model has a number of advantages that make it relevant in 21st century learning. CPS encourages students to come up with alternative solutions through a divergent thinking process, before then selecting and focusing ideas through a convergent thinking process, so that students are not fixated on a single answer (Treffinger & Isaksen, 2013). In addition, CPS develops evaluative skills because students need to weigh the strengths and weaknesses of each idea, which is part of the "appraising tasks" and "developing solutions" stages within the framework of CPS version 6.1, thus practicing systematic critical reasoning (Suryaningsih & Zulfatunnisa, 2025). CPS also increases student motivation and engagement through a collaborative, contextual, and well-structured problem-solving process, as shown in research, who found that CPS significantly improved the quality of student participation and divergent thinking skills in thematic learning in primary schools (Aytekín & Topçu, 2024; Fathonah et al., 2024; Lee & Lee, 2024). Furthermore, recent international research shows that CPS in learning design is able to effectively train high-level thinking skills such as critical, creative, and argumentative thinking, as CPS integrates problem exploration with the development of logical and innovative solutions (Endrawati Subroto et al., 2023; Van Hooijdonk et al., 2023a). These findings confirm that CPS is an approach that not only encourages creativity, but also strengthens critical reasoning and collaborative skills that are so much needed in the demands of 21st century learning.

Recent research continues to demonstrate the effectiveness of the Creative Problem Solving (CPS) model in supporting higher-order thinking skills across various educational contexts. A meta-analysis found that CPS yields a high effect size (0.655) on students' mathematical problem-solving abilities, confirming its strong impact across diverse sample groups and instructional settings (A. Rahmawati et al., 2023a). A more recent study also showed that CPS-based instruction in mathematics significantly enhances learners' creative thinking skills, emphasizing the model's role in fostering divergent and flexible thought processes essential to advanced cognition (Ersoy & Kara, 2026). Complementing these findings, reported that CPS effectively improves creative thinking performance in mathematics problem-solving tasks when analyzed across different levels of students' self-regulated learning, indicating that CPS supports cognitive development even among diverse learner profiles (Hamid et al., 2024).

Although these studies collectively reinforce the potential of CPS in improving creative thinking, problem-solving skills, and other forms of higher-order cognition, empirical evidence specifically focused on critical thinking skills particularly in elementary level mathematics remains limited. Some recent studies have explored related models such as Collaborative Problem Solving, showing positive effects on students' critical thinking skills, yet these models differ methodologically from the classical CPS framework (Sasanti, 2025). Moreover, many CPS studies incorporate supplementary learning tools, digital media, or contextual approaches, making it difficult to isolate the pure effectiveness of CPS in conventional classroom environments. Therefore, further research that directly examines the independent influence of CPS on students' critical thinking skills without technological or media-based enhancements is still needed to address this gap and provide a clearer empirical foundation for CPS implementation in face-to-face mathematics instruction.

This gap forms the foundation for conducting further research on the effectiveness of the CPS model in improving elementary students' critical thinking skills. While previous studies have predominantly highlighted CPS as a model that effectively enhances creative thinking and mathematical problem-solving abilities (A. Rahmawati et al., 2023b) as well as creative thinking performance in secondary and elementary contexts (Hamid et al., 2024), empirical investigations targeting critical thinking remain limited. More recent work has emphasized CPS's strong influence on creative and divergent thinking skill (Ersoy & Kara, 2026), yet studies examining the direct effect of CPS on critical thinking, especially within mathematics learning at the elementary level, are still scarce. Existing research on related models such as Collaborative Problem Solving has shown promise for improving critical thinking skills (Sasanti, 2025), but these approaches differ conceptually and procedurally from classical CPS, leaving the role of CPS itself underexplored in this cognitive domain.

Furthermore, most earlier CPS studies have been conducted using broad mathematical content or supplemented with additional technological media, making it difficult to isolate the pure impact of CPS in face-to-face classroom settings. The present study therefore provides an important contribution by examining CPS specifically in the context of speed, distance, and time, a mathematical topic that has received limited attention in prior CPS related literature. By focusing on critical thinking skills measured through Ennis' indicators representing a core high-level cognitive domain this study enriches current literature and offers a more comprehensive understanding of how CPS can be effectively implemented to strengthen critical thinking in elementary mathematics learning.

This research also contributes to the research status by strengthening the findings of previous research related to the effectiveness of CPS, but expanding its scope to critical thinking aspects that have not been widely explored. By providing empirical evidence that CPS not only enhances creativity, but also critical thinking skills, this study provides a relevant new understanding for teachers and schools in improving math learning strategies.

Based on this description, this study aims to analyze the influence of the Creative Problem Solving learning model on the critical thinking skills of grade VI students at MI Assa'adatuddarain 1 Pamulang. The findings of this research are expected to make a theoretical and practical contribution to the development of mathematics learning that is more innovative, meaningful, and oriented towards strengthening students' high-level thinking skills.

Methods

This study employs a quantitative approach using a quasi-experimental method with a Posttest-Only Control Group Design, a design widely recommended in recent educational research when random assignment is not feasible and classes are already pre-formed. According to contemporary methodological literature, quasi-experimental designs are particularly suitable for real classroom settings where randomized controlled trials cannot be implemented. In addition, recent analyses highlight that when randomization is not possible, the Posttest-Only Control Group Design implemented without pretesting serves as a strong alternative for evaluating the effects of instructional interventions (Cham et al., 2024).

Table 1. Research Design

Group	Treatment	Post Test
Experiment	X_E	Y
Control	X_C	Y

In this study, the experimental group (X_e) received a learning intervention using the CPS model, whereas the control group (Xc) underwent conventional, teacher-centered instruction. After the treatment period, both groups were administered the same posttest (Y) measuring critical thinking skills to determine whether differences in outcomes could be attributed to the learning model applied. This aligns with the logic of the posttest-only design, which evaluates the impact of an intervention by directly comparing the results of treated and untreated groups.

The research population consisted of all sixth-grade students of MI Assa’adatuddarain 1 Pamulang in the 2024/2025 academic year. Because the school used intact classroom groupings that could not be randomly rearranged, the sampling procedure employed a cluster sampling technique, which is widely recommended in contemporary educational research when participants are naturally grouped in pre-existing classes. Two clusters were selected: one assigned as the experimental class, receiving instruction through the CPS model, and the other as the control class, taught using conventional teacher-centered methods. The total sample consisted of 54 students, with 27 students assigned to the experimental group and 27 students assigned to the control group. The learning intervention was implemented over a two-month period, from October to November 2024, covering several phases: preparation of instructional materials, validation of research instruments, delivery of the CPS-based learning activities, and posttest administration for both groups. This structure ensured that the comparison between groups reflected the impact of the learning model rather than variations in instructional time or curriculum exposure.

The primary research instrument was an essay-type test designed to measure students' critical thinking skills based on Ennis' indicators, which include elementary clarification, basic support, inference, advanced clarification, and strategies and tactics. The development of this instrument followed rigorous procedures to ensure methodological soundness. First, the initial set of nine questions underwent content validation by subject-matter experts, who evaluated the alignment between the test items, the mathematical content, and the critical-thinking indicators. Following this expert review, the instrument was subjected to empirical validation through a trial administered to a comparable group of students. Item-analysis procedures were conducted, producing six valid items that met the required statistical criteria. The internal consistency of the final instrument was evaluated using Cronbach's Alpha, resulting in a reliability coefficient of 0.763, which falls within the category of high reliability. This indicates that the instrument yields stable and consistent measurements, making it suitable for assessing students' critical thinking abilities in the context of this quasi-experimental study. In general, the research procedure carried out in this study is illustrated in the figure below.

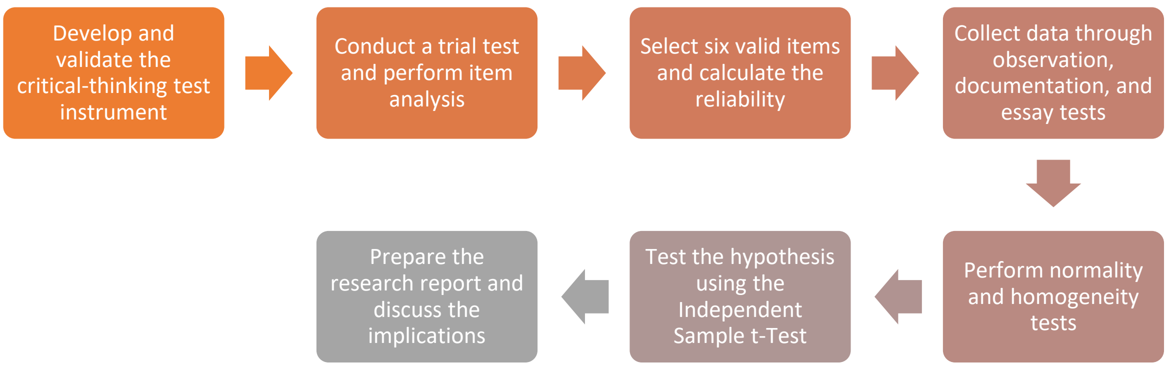


Figure 1. Research Flowchart

The research flowchart illustrates the sequential stages undertaken throughout the study. The process begins with data collection, which involves three primary techniques: observation to obtain information on classroom conditions and learning activities, documentation to gather supporting data such as class records and school information, and an essay test administered to measure students' critical thinking skills. Before being used in the study, the critical-thinking test instrument underwent a series of quality assessments to ensure that it met the standards of a valid and reliable measurement tool. The instrument was evaluated through validity testing, reliability testing, difficulty-level analysis, and discrimination-index analysis. Based on the Product Moment validity test, six of the nine items met the criterion $r_{hit} > r_{taβle}$ (0.4438), indicating that these items were appropriate for assessing students' critical-thinking skills. After this instrument validation stage, the research continued to analysis assumptions, consisting of normality testing and homogeneity testing. These prerequisite tests are essential to determine whether the data meet the conditions required for parametric statistical analysis. Once the assumptions are met, the study proceeds to hypothesis testing using the Independent Sample t-Test, which compares the mean scores of the experimental and control groups to determine whether there is a statistically significant difference in their critical-thinking abilities. The results of the t-test lead to conclusions, either rejecting the null hypothesis indicating that the CPS model enhances critical thinking skills or accepting the null hypothesis, meaning that the CPS model has no significant effect. The research process concludes with the preparation of the research report and implications, summarizing the findings and outlining the educational significance of applying the CPS learning model.

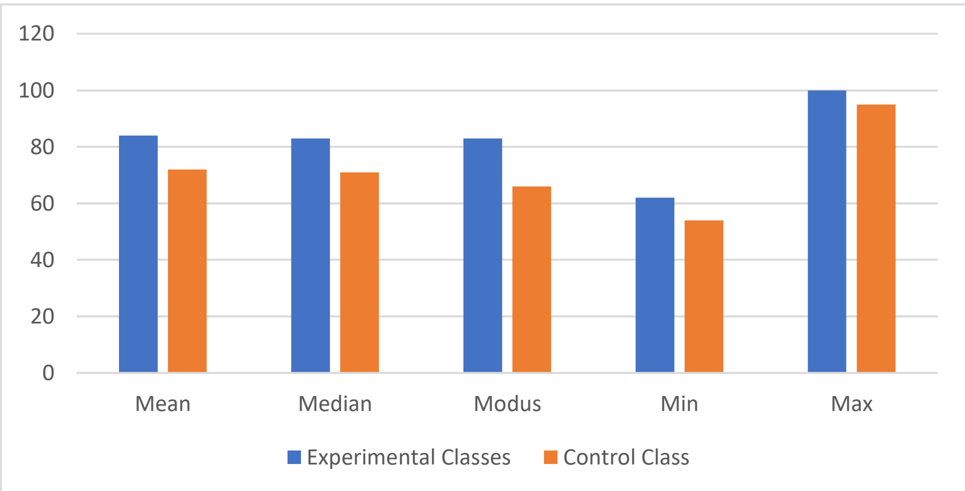
Result

The results of the research on students' critical thinking skills were obtained through the implementation of posttests in both groups after the implementation of learning, presented in the following table.

Table 2. Descriptive Statistics of Posttest Scores

Statistics	Experimental Classes	Control Class
Mean	84.07	72.80
Median	83	71
Modus	83	66
Min	62	54
Max	100	95

The following figure presents a comparison of descriptive statistics of *the results of the critical* thinking ability posttest between the experimental class and the control class.



Graph 1. Descriptive Statistics of Posttest Scores

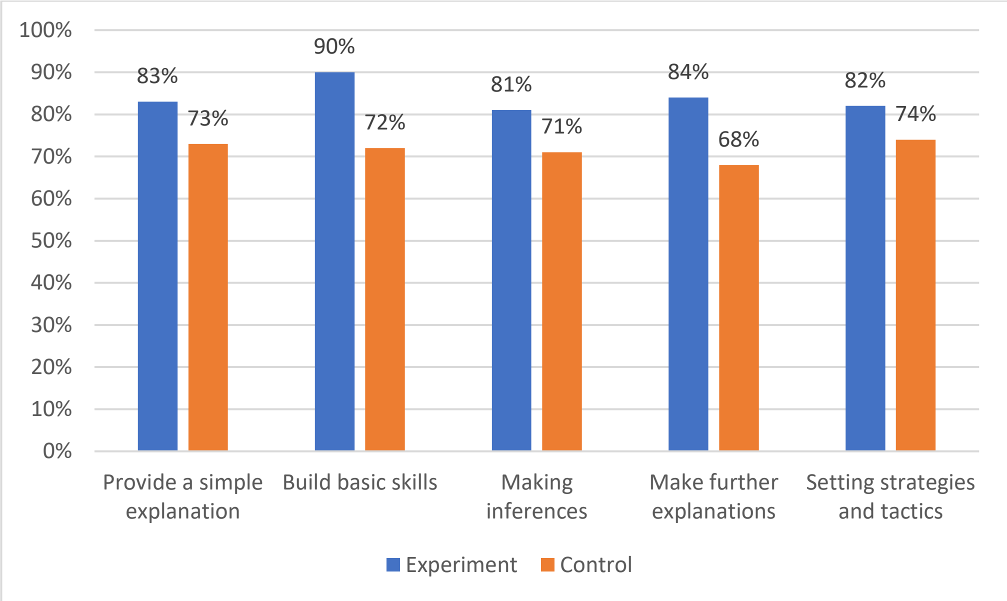
The statistics displayed include the mean, median, mode, minimum score, and maximum score, which provide a comprehensive picture of the distribution and central tendency of student achievement in each group. This visualization aims to show the difference in student performance after the application of the CPS learning model in the experimental class and conventional learning in the control class. Through the graph, it can be seen that the experimental class obtained higher mean, median, and maximum scores, as well as a more stable score range compared to the control class. These findings indicate that CPS provides students with more structured opportunities to identify problems, generate alternative strategies, evaluate possible solutions, and justify their reasoning. Theoretically, this is in line with the CPS framework, which emphasizes divergent and convergent thinking processes in solving problems creatively and systematically (Osborn, 1953; Treffinger, 2007). In the context of mathematics learning, especially the material of speed, distance, and time, CPS enables students to connect concepts, analyze relationships among variables, and select appropriate solution strategies, which are essential components of critical thinking (Ennis R, 2015; Facione, 1990). The higher achievement of the experimental class also supports constructivist learning theory, which argues that students develop deeper understanding when they are actively involved in constructing knowledge through exploration, discussion, and reflection (Piaget, 1976; Vygotsky, 1978). Therefore, the graphical presentation not only describes the difference in student achievement between the two groups but also provides theoretical support for understanding the effectiveness of the CPS model in improving students' critical thinking skills in mathematics.

The students' critical thinking skills in this study are based on five indicators, namely Providing simple explanations, Building basic skills, Making inferences, Making further explanations, Organizing strategies and tactics. The critical thinking ability scores of students in the experimental group and the control group based on the critical thinking ability indicators are presented in the following table:

Table 3. Average Score of Mathematical Critical Thinking Ability Indicator of Experimental Class and Control Class

Critical thinking indicators	Experiment			Control		
	Ideal Score	Student Score	%	Ideal Score	Student Score	%
Provide a simple explanation	112	94	83%	104	76	73%
Build basic skills	112	101	90%	104	75	72%
Making inferences	112	91	81%	104	74	71%
Make further explanations	112	95	84%	104	71	68%
Setting strategies and tactics	224	185	82%	208	155	74%

Based on the table, the critical thinking ability of the experimental class was also better than that of the control class. Visually, a comparison of critical thinking ability on each indicator between the experimental class and the control class can be further seen in the following Graphics.



Graph 2. Average Score of Mathematical Critical Thinking Ability Indicator of Experimental Class and Control Class

Overall, the achievement of critical thinking ability in each indicator showed that the experimental class that received learning with the Creative Problem Solving (CPS) model had a higher percentage score than the control class. The experimental class reached 83% on the indicator of providing simple explanations, 90% on building basic skills, 81% on making inferences, 84% on making further explanations, and 82% on setting strategies and tactics. In contrast, the control class only reached 68–74% across all indicators. This pattern indicates that CPS consistently improves various dimensions of critical thinking, from the ability to provide simple reasons to the ability to develop comprehensive problem-solving strategies. These findings are supported by Van Hooijdonk et al. (2023), who found that the CPS model can be applied in the primary-school context and that primary students are already capable of engaging in creative problem-solving processes, including understanding challenges, generating ideas, preparing actions, and planning approaches. This is also in line with O'Reilly et al. (2022), whose systematic review showed that children's critical thinking can be developed through classroom interaction, dialogue, questioning techniques, thinking language, and problem-solving activities. Furthermore, Wang & Abdullah (2024) emphasized that critical thinking in mathematics learning is strengthened when instructional interventions involve clear thinking objectives, authentic tasks, dialogue, collaborative activities, and assessment instruments aligned with critical-thinking indicators. Therefore, the stronger and more evenly distributed performance of the experimental class suggests that CPS is not only effective in increasing students' achievement scores but also supports the development of critical thinking as a structured, reflective, and strategic reasoning process in mathematics learning.

Before the hypothesis test was carried out, a prerequisite test was carried out in the form of normality and homogeneity tests. The results of the normality test showed that the data in both groups were distributed normally. The homogeneity test showed that the variance of the two groups was homogeneous and therefore qualified for parametric analysis using the Independent Samples t-test. The following results of the statistical hypothesis test are presented in the image.

Table 4. Statistical Test Results Using SPSS

Independent Samples Test										
		Levene's Test		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of Difference	
									Lower	Upper
Post test	Equal variances assumed	.412	.524	-3.788	52	.000	-11.995	3.167	-18.349	-5.640
	Equal variances not assumed			-3.77	50.027	.000	-11.995	3.181	-18.385	-5.604

The results of the Independent Samples t-test showed that the significance value was $p < .001$, which was lower than the significance level of .05. Thus, there was a statistically significant difference between the critical thinking skills of students in the experimental class and those in the control class. The t-test result, $t(52) = -3.788$, $p < .001$, with a mean difference of -11.995 and a 95% confidence interval ranging from -18.349 to -5.640, indicates that the difference between the two groups was not caused by chance. The negative value of the mean difference reflects the order of group coding in SPSS; substantively, the result shows that students taught using the CPS model achieved better post-test performance than those taught using conventional instruction. This finding is closely related to the concept of critical thinking. In this study, critical thinking refers to students’ ability to understand problems, interpret information, analyze relationships among concepts, evaluate solution strategies, draw logical conclusions, and justify answers based on evidence. Facione (2015) defines critical thinking as purposeful and self-regulatory judgment involving interpretation, analysis, evaluation, inference, explanation, and self-regulation. Ennis (2011) also describes critical thinking as reasonable and reflective thinking focused on deciding what to believe or what to do. In mathematics learning, critical thinking is not only shown by students’ ability to produce correct answers, but also by their ability to understand the problem context, select appropriate procedures, check the reasonableness of their results, and explain the logic behind their solutions.

In the topic of speed, distance, and time, critical thinking is particularly important because students are required to do more than memorize and apply formulas. They must identify the known and unknown information, determine the relationship among speed, distance, and time, choose the correct formula, and evaluate whether the final answer is reasonable in a real-life context. Therefore, students’ critical thinking skills can be seen from how they analyze word problems, organize relevant information, solve problems systematically, and provide rational explanations for their answers. The CPS model supports the development of critical thinking because it guides students through problem clarification, idea generation, strategy selection, solution implementation, and evaluation. Treffinger et al. (2006) explain that CPS integrates creative and critical thinking in solving problems.

Creative thinking helps students generate various possible ideas or strategies, while critical thinking helps them examine, select, and justify the most appropriate solution. This means that CPS does not only encourage students to find answers, but also trains them to think logically, compare alternatives, and reflect on the accuracy of their solutions.

The effectiveness of CPS in improving critical thinking is also supported by Halpern, (2013) view that critical thinking can be developed through explicit instruction, structured practice, metacognitive monitoring, and the transfer of thinking skills across different contexts. In mathematics classrooms, CPS provides opportunities for students to engage in reasoning, discussion, argumentation, and reflective problem solving. These activities are essential for developing higher-order thinking skills. This is in line with the NCTM, (2009) which emphasizes that mathematics learning should promote reasoning, problem solving, meaningful discourse, and the use of evidence in explaining mathematical ideas.

Thus, the significant difference found in this study provides empirical support that the CPS model contributes positively to improving sixth-grade students' critical thinking skills in learning speed, distance, and time. The improvement occurred because CPS encouraged students to actively identify problems, explore different solution strategies, discuss ideas, justify their answers, and reflect on their learning process. This kind of learning experience is more effective than conventional instruction because students are not only asked to follow procedures, but are also trained to think critically and independently.

Discussion

The results showed that there was a significant difference between the critical thinking skills of students in the experimental class who learned using the CPS model and the control class who learned using conventional learning. Descriptively, the experimental class obtained a higher score on all statistical parameters. This achievement is in line with the characteristics of the CPS model which is designed to activate the two main thinking patterns, divergent thinking and convergent thinking, which work in harmony in the process of solving complex problems (Isaksen et al., 2011; Treffinger & Isaksen, 2013). The ideation stage in CPS encourages students to come up with a variety of alternative solutions, while the convergence stage directs students to evaluate and choose the best ideas, a process that directly stimulates students' critical thinking abilities.

When viewed based on the indicators of critical thinking ability, the experimental class showed excellence in all Ennis indicators, ranging from the ability to provide simple explanations, build basic skills, make inferences, provide further explanations, to the ability to set strategies and tactics. The dominance of the "build basic skills" (90%) and "make further explanations" (84%) indicators in the experimental class showed that CPS was able to help students gather evidence, evaluate information, and structure arguments in a more structured way than traditional learning. This is consistent with findings showing that the CPS model has been proven to be more effective than direct instruction in improving students' divergent thinking skills and argumentation quality in the context of thematic problem solving in elementary schools (Aytekín & Topçu, 2024; Tsai & Hsu, 2024).

The findings of the study show that the application of CPS significantly improves students' critical thinking skills compared to conventional teacher centered instruction. These results are in line with recent meta-analyses confirming the high effect of CPS on mathematical problem-solving performance as a gateway to strengthening critical reasoning in elementary grades as well as with recent studies documenting the contribution of CPS to the development of divergent and convergent thinking in mathematics. Thus, increased active participation, exploration of alternative solutions, and sharper argumentation in experimental classrooms are patterns consistent with the latest literature (Arifin et al., 2025; Nabila & Suryaningsih, 2023).

In the process, CPS facilitates the Clarify–Ideate–Develop–Implement step which is naturally aligned with Ennis' critical thinking indicators (simple clarification, basic support, inference, further clarification, and strategies and tactics). The CPS framework guides students to clarify challenges, collect data, generate ideas, and then filter and test solutions based on criteria that all require reasoning, evaluation of evidence, and justification of decisions. With a well-established foundation of definitions and indicators of critical thinking (Ennis), the mapping of the CPS stage to the assessment indicators in this study has strong theoretical support (Orhan, 2023).

In the Basic Tools stage, students in the experimental class showed excellence in elementary clarification and basic support: identifying the core of the problem, developing solution steps, and maintaining unit consistency (e.g. when converting m/min to km/h). This pattern is logical because CPS's initial activities emphasize clarifying issues and gathering relevant data, while structured discussions help students question and answer and evaluate simple statements. Empirical evidence suggests that cooperative/group learning in elementary school significantly improves analytical rigor and understanding of basic concepts that underpin initial arguments in line with those observed in students' answers in experimental classrooms (Heidorn & Hokanson, 2025).

In the Practice with Process stage, students practice applying concepts through cases and analogies (e.g. estimating travel time and checking unit consistency), so that advanced clarification and inferring indicators are encouraged. Recent synthesized evidence shows a large average effect of inquiry-based learning on critical thinking and quasi-experimental findings in elementary school confirm the significant positive influence of investigative activities on mathematical CT; These two findings explain why the practice of the process (proposing hypotheses, testing evidence, inferring) at this stage strengthens students' inferential abilities. On the assessment side, the use of open-ended assignments with rubrics that demand justification and evaluation of solutions has been proven to facilitate a more structured articulation of reasons (Maker et al., 2023).

In the Working with Real Problems stage, students design strategies, choose the right representation/unit, and evaluate solutions to the criteria; The experiment class answers show more systematic decision-making. Recent literature shows that the quality of exploratory interaction in group discussions (asking questions, building arguments, peer clarification) is associated with deeper conceptual understanding and more appropriate problem-solving strategies. The practice of peer-assessment has also been shown to enrich solution evaluation and foster metacognitive monitoring, an important component of strategy and tactics indicators. (Hamid et al., 2024).

In a broader context, the effectiveness of CPS in improving higher-level thinking skills has been supported by various international studies. Lee & Lee, (2024) found that the CPS model when integrated into science learning is able to improve five key thinking skills, namely science literacy, science processes, argumentation, creativity, and critical thinking, which are the core of Higher-Order Thinking Skills (HOTS) in the 21st century curriculum.

The advantages of CPS in this study can also be understood through the lens of constructivism theory, which emphasizes that students actively build knowledge through interaction and exploration. CPS provides a space for students to explore ideas, test hypotheses, and reflect on their thought processes. When students are actively engaged in problem clarification and idea assessment, they develop more mature critical thinking skills. This is in line with the results of international research showing that problem-based learning strategies and cognitive exploration are one of the most effective approaches to improving the critical thinking skills of primary school students.

Conclusion

Based on the results of the research that has been conducted, it can be concluded that the application of the CPS learning model has a significant influence on improving the critical thinking skills of grade VI students in the material of speed, distance, and time. Comparison of posttest scores showed that students in the experimental class consistently obtained higher scores than the control class, both in terms of average, median, and highest scores. In addition, the analysis of critical thinking skills based on Ennis' indicators also showed that the experimental class excelled in all indicators, including the ability to provide simple explanations, build basic skills, make inferences, provide further explanations, and set strategies and tactics. The results of the statistical test through the Independent Samples t-test confirm that the difference is significant, so it can be said that the CPS model is effective in facilitating high-level thinking processes, especially critical thinking skills. The learning process that emphasizes the stages of problem clarification, ideation, solution development, and implementation has been proven to be able to encourage students to be more active in exploring information, assessing alternative solutions logically, and making the right decisions. Thus, the CPS model is worthy of being recommended as an alternative mathematics learning strategy that can improve students' critical thinking skills comprehensively within the scope of elementary mathematics instruction.

However, this study has several limitations. First, the research was conducted in a single elementary school, so the findings may not be fully generalizable to other school contexts with different student characteristics, teacher competencies, and classroom cultures. Second, this study used a quasi-experimental posttest-only control group design without a pretest, so the initial equivalence of the experimental and control groups could not be statistically confirmed before the intervention. Third, the intervention was carried out for only two months, which may be sufficient to identify the immediate effect of the CPS model but may not fully capture the long-term development of students' critical thinking skills. Fourth, this study did not include a follow-up assessment or delayed posttest, so the retention of students' critical thinking skills after the intervention remains unknown. Therefore, future studies are recommended to involve larger and more diverse samples, apply a pretest-posttest design, extend the duration of the intervention, and conduct follow-up assessments to examine the sustainability of the CPS model's impact on students' critical thinking skills.

Declarations

Author contribution statement

The author contributed to all stages of the research process, including the development of the research design, data collection, data analysis, and interpretation of results. The first author contributed to the conceptualization of the study, research design, instrument development, data collection, and preparation of the initial manuscript draft. The second author contributed to methodology refinement, data analysis, interpretation of findings, literature review, manuscript revision, editing, and final approval of the manuscript. Both authors have read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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Data availability statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request. All datasets generated or analyzed during this research remain stored securely and can be accessed for verification or further study.

Declaration of interests statement

The author declares that there are no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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