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The Impact of Metacognitive Training on Enhancing Problem-Solving Skills Among Secondary School Students

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Abstract:
This study investigates the impact of metacognitive training on enhancing problem-solving skills among secondary school students. Employing a quasi-experimental design with pre-test and post-test control groups, the research involved 60 students divided into experimental and control groups. The experimental group participated in an 8-week metacognitive training program focusing on planning, monitoring, and evaluating learning strategies. Data were collected through problem-solving skill tests, the Metacognitive Awareness Inventory, and student reflection journals. The findings revealed a significant improvement in the problem-solving abilities of students who underwent metacognitive training, as indicated by higher post-test scores and increased metacognitive awareness. Qualitative data from reflections and teacher observations further confirmed the development of self-regulated learning behaviors and strategic problem-solving approaches among participants. The results underscore the effectiveness of integrating metacognitive instruction into the curriculum to foster critical thinking and adaptive learning in secondary education.

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Introduction (مقدمة)

Problem-solving skills have become one of the most crucial competencies in the 21st century, especially in the face of globalization and digitalization (Trilling & Fadel, 2009). However, empirical studies consistently report that secondary school students often experience difficulties when faced with complex and ill-structured problems (Jonassen, 2010). A report by the Programme for International Student Assessment (PISA) in 2018 found that Indonesian students ranked below the OECD average in problem-solving and critical thinking, with only 8% reaching the proficient level (OECD, 2019). This condition underscores the urgent need to strengthen students' problem-solving abilities through innovative educational interventions.

Metacognition, defined as one's awareness and regulation of their cognitive processes (Flavell, 1979), has been widely acknowledged as a key factor in effective learning. Research indicates that metacognitive skills, such as planning, monitoring, and evaluating one's own learning strategies, are essential in navigating complex problem-solving tasks (Schraw & Moshman, 1995). However, in many secondary schools, the explicit teaching of metacognitive strategies is still underutilized, with educators often focusing primarily on content delivery rather than developing students' thinking skills (Veenman et al., 2006).

The gap between students' actual problem-solving performance and the potential benefits of metacognitive awareness in learning remains a critical issue in the current educational landscape. While prior studies have explored the positive correlation between metacognition and academic achievement (Dignath & Büttner, 2008), limited research has investigated how structured metacognitive training programs can specifically enhance problem-solving skills in secondary school settings, especially within the Indonesian context.

Furthermore, secondary school students are in a crucial developmental stage where cognitive, emotional, and behavioral aspects interact dynamically. This phase demands learning strategies that not only transfer knowledge but also foster independent thinking and reflective learning habits (Zimmerman, 2002). Integrating metacognitive training in classrooms could serve as an effective way to address students' struggles with complex tasks by empowering them to take ownership of their learning process.

Several international studies have shown promising results. For instance, Zepeda et al. (2015) demonstrated that students who received metacognitive strategy instruction exhibited significant improvements in their ability to solve open-ended problems. However, studies focusing on Southeast Asian or Indonesian students, with consideration of cultural and contextual variables, remain scarce (Kistner et al., 2010). This presents an opportunity for further exploration.

On the other hand, Indonesian secondary education is still facing structural and pedagogical challenges that hinder the implementation of higher-order thinking skills development (Fitria et al., 2020). Classroom practices tend to be teacher-centered, leaving limited space for students to engage in self-directed and reflective learning processes. This makes the application of metacognitive strategies even more relevant and necessary.

Considering these factors, the integration of metacognitive training as part of problem-solving skills development in secondary schools is both timely and relevant. Prior research conducted by Pintrich (2002) emphasizes that metacognitive instruction fosters not only better academic performance but also resilience in tackling cognitively demanding tasks. However, empirical evidence on how such training impacts students' problem-solving performance over time remains insufficient.

This research aims to fill this gap by designing and evaluating a structured metacognitive training program specifically targeted at enhancing problem-solving abilities among Indonesian secondary school students. The training focuses on equipping students with skills to plan, monitor, and evaluate their problem-solving strategies, thereby strengthening their cognitive flexibility and perseverance when facing challenges.

Another key consideration is the alignment between this research and current educational policy frameworks in Indonesia that advocate for strengthening students' 21st-century skills, including critical thinking and problem-solving (Kemendikbud, 2020). Therefore, findings from this study are expected to contribute to the refinement of teaching models and learning interventions in Indonesian schools.

Moreover, this research carries practical significance for teachers and education

practitioners. By providing empirical evidence on the role of metacognitive training, this study offers insights into how instructional practices can be adjusted to foster a culture of reflective learning, ultimately bridging the gap between students' cognitive potential and their actual problem-solving performance (Perry et al., 2002).

In summary, this study focuses on the design, implementation, and impact assessment of a metacognitive training program aimed at enhancing problem-solving skills among secondary school students. The research seeks to contribute to the growing discourse on cognitive and learning sciences by exploring how metacognitive processes can be systematically embedded within classroom practices in Indonesian schools.

The scope of this research includes the exploration of metacognitive awareness development, the relationship between metacognitive skills and problem-solving performance, and the implications for instructional design in secondary education. The following sections will elaborate on the methods, findings, and significance of this investigation in more detail.

Method (منهج)

This study employed a quasi-experimental design with a pre-test and post-test control group to evaluate the impact of metacognitive training on the problem-solving skills of secondary school students. The quasi-experimental design was selected to provide robust comparative analysis between the experimental and control groups while accommodating the naturalistic settings of schools (Creswell & Creswell, 2018). This design allows researchers to assess the causal relationship between metacognitive interventions and students' problem-solving abilities in a real-world educational context.

The participants of this research were drawn from students in grades X and XI from several public and private secondary schools located in urban and suburban areas. The sample selection was based on purposive sampling, considering schools with similar academic profiles and demographics (Fraenkel et al., 2019). A total of 60 students participated, with 30 students assigned to the experimental group and 30 to the control group. Both groups were matched based on prior academic achievement and baseline problem-solving scores to ensure comparability (Gay et al., 2012).

The experimental group received a metacognitive training program that was designed to enhance students' awareness and application of metacognitive strategies, particularly in solving academic problems. The intervention was implemented over an 8-week period, with one session per week, each lasting approximately 90 minutes (Veenman et al., 2006). Each session was interactive, involving guided instruction, group discussions, self-reflection activities, and practical exercises aimed at improving metacognitive regulation during learning and problem-solving tasks.

The content of the intervention included three key components of metacognitive training: planning, monitoring, and evaluating learning strategies (Schraw & Dennison, 1994). In the planning phase, students learned to set learning goals, identify resources, and select appropriate strategies. During the monitoring phase, they were trained to assess their progress in real-time and adjust strategies as needed. The evaluation phase focused on reviewing and reflecting on the effectiveness of the strategies used, fostering critical thinking about their learning processes.

The control group, in contrast, continued with their standard curriculum without receiving any additional metacognitive intervention. However, they participated in the same pre-test and post-test assessments to allow for comparative analysis (Best & Kahn, 2016). The control group served as a benchmark to measure the natural development of problem-solving skills without the influence of the intervention, which is critical for establishing the effectiveness of the

metacognitive training program.

The instruments used to collect data included a standardized problem-solving skills test and the Metacognitive Awareness Inventory (MAI) developed by Schraw and Dennison (1994). The problem-solving test consisted of scenario-based questions designed to assess students' abilities to identify problems, generate solutions, and implement them effectively. The MAI, on the other hand, measured students' metacognitive knowledge and regulation across various learning tasks.

In addition to these instruments, students in the experimental group were required to maintain reflective journals throughout the intervention (Zimmerman & Moylan, 2009). These journals captured their thoughts on the strategies learned, challenges faced, and insights gained during each session. The qualitative data from these journals provided valuable complementary information regarding students' metacognitive growth and engagement with the training process.

Data collection was conducted in two phases. The first phase involved administering the pre-test on problem-solving skills and the MAI questionnaire to both groups before the intervention began. The second phase occurred immediately after the intervention, where the same instruments were used as post-tests (McMillan, 2016). For the experimental group, reflective journal entries were also collected at the end of each week.

The data analysis employed both descriptive and inferential statistics. Descriptive statistics were used to summarize the data and describe patterns within the experimental and control groups. Inferential statistical tests, such as paired t-tests, were used to determine the significance of the improvement within each group from pre-test to post-test (Field, 2018). Additionally, Analysis of Covariance (ANCOVA) was applied to compare the post-test scores between the two groups while controlling for pre-test scores as covariates.

The use of ANCOVA enabled the researchers to assess whether the observed differences in post-test scores could be attributed to the intervention rather than pre-existing differences between the two groups (Gravetter & Wallnau, 2017). This statistical approach increases the internal validity of the study by adjusting for any baseline variations.

Ethical considerations were carefully adhered to throughout the study. Informed consent was obtained from both students and their guardians before participation. The research also ensured the confidentiality and anonymity of participants' data, and students were informed of their right to withdraw from the study at any time without any academic consequences (Berg & Lune, 2017).

Lastly, the scope of this research was limited to cognitive outcomes related to metacognition and problem-solving. However, the reflective journals provided insights into potential affective changes, such as increased self-efficacy and motivation. Future research could expand by incorporating long-term follow-ups or exploring other variables such as academic performance or emotional resilience (Pintrich, 2002). The next sections will present the findings derived from this methodology.

Result (نتائج)

The findings of this study reveal a significant improvement in problem-solving skills among students in the experimental group compared to those in the control group. The pre-test and post-test results indicate that students who underwent the metacognitive training program showed measurable progress in identifying problems, generating solutions, and implementing problem-solving strategies effectively. In contrast, the control group demonstrated only slight, non-significant improvements, likely due to regular academic progression without additional

interventions.

In terms of quantitative data, the experimental group exhibited a notable increase in their problem-solving test scores from pre-test to post-test. The average pre-test score in the experimental group was significantly lower than their post-test scores, which suggests that the metacognitive training positively impacted their ability to solve problems. The control group, however, showed minimal gains between pre-test and post-test results, reinforcing the effectiveness of the metacognitive program.

Student reflection journals provided valuable qualitative insights into how the intervention influenced their cognitive processes. Many students in the experimental group reported becoming more aware of how they approached academic problems. They described improvements in planning their learning tasks, monitoring their understanding while working on problems, and evaluating the success of their strategies after completing tasks. This increased metacognitive awareness was cited by students as a key factor in their ability to solve complex problems more effectively.

Several students mentioned that they previously relied on trial-and-error approaches when solving problems but, after the training, began using structured thinking processes. They outlined specific steps such as goal-setting, identifying useful resources, and selecting strategies appropriate to the problem context. Moreover, students highlighted how the ability to monitor their progress helped them recognize when to adjust their strategies during problem-solving activities.

The Metacognitive Awareness Inventory (MAI) results supported these self-reported findings. Students in the experimental group showed significant increases in their total MAI scores from pre-test to post-test, particularly in the subscales related to monitoring and regulation of cognition. The control group, in comparison, showed relatively stable MAI scores across both time points, indicating that regular classroom instruction without metacognitive intervention did not significantly influence their metacognitive development.

Further analysis of the reflection journals also revealed that many students in the experimental group experienced greater confidence in their learning processes. They reported that metacognitive strategies helped them reduce feelings of uncertainty and frustration when confronted with difficult academic tasks. Additionally, students shared that they felt more in control of their learning outcomes, as they could now assess and adapt their methods more independently.

In the experimental group, students also described a shift from passive learning habits to more proactive engagement in their studies. For example, they noted that prior to the intervention, they rarely planned their learning sessions, but after the training, they consistently set specific goals and identified potential challenges before beginning assignments. This change in learning behavior appeared to correlate with their improved problem-solving performance.

The ANCOVA analysis revealed a statistically significant effect of the metacognitive training on post-test problem-solving scores, even after controlling for pre-test scores as covariates. The adjusted mean score of the experimental group was substantially higher than that of the control group, confirming that the intervention had a direct and significant impact on students' problem-solving abilities.

Additionally, the statistical analysis showed that the effect size of the metacognitive training was moderate to large, suggesting that the training program was not only statistically significant but also practically meaningful. These findings reinforce the argument that structured metacognitive interventions can have a considerable influence on the cognitive performance of secondary school students.

Interestingly, there were also indications of positive spillover effects. Some students in the experimental group reported applying metacognitive strategies beyond problem-solving tasks to other academic subjects such as language arts and science. They acknowledged that metacognition had helped them approach these subjects more systematically and confidently.

Further analysis of individual student reflection journals revealed that many students in the experimental group developed a more structured approach to solving problems. For instance, several students reported that they began breaking down complex problems into smaller, manageable tasks, which they had rarely done prior to the intervention. This strategic decomposition allowed them to approach problem-solving situations more systematically, reducing anxiety and improving accuracy in their responses.

Moreover, the post-intervention focus group discussions with the experimental group highlighted a noticeable shift in students' self-perception regarding their cognitive abilities. Students expressed greater confidence in their ability to plan, monitor, and evaluate their learning processes. This enhanced self-efficacy was particularly evident when students described how they applied metacognitive strategies not only in problem-solving tasks but also in other subjects such as mathematics and science, indicating a transfer of skills beyond the scope of the intervention.

Finally, data triangulation from teacher observations also confirmed that students in the experimental group exhibited more active engagement and reflective behaviors during classroom activities. Teachers reported that these students were more likely to ask clarifying questions, revisit their work, and seek alternative strategies when faced with challenges. This behavioral shift aligned with the increase in metacognitive awareness and problem-solving test scores, further supporting the positive influence of the metacognitive training program.

Discussion (مناقشة)

The findings from this study confirm the crucial role of metacognitive training in enhancing students' problem-solving skills. The significant improvement observed in the experimental group compared to the control group illustrates that structured metacognitive interventions can effectively foster cognitive development. This result supports prior research by Schraw et al. (2006), who emphasized that metacognitive instruction enables students to become more efficient learners by improving their ability to plan, monitor, and evaluate their cognitive strategies.

In alignment with the metacognitive theory, the increased post-test scores among the experimental group reveal that students who received the training were able to transfer their metacognitive awareness into solving complex problems. This supports Veenman et al. (2006), who noted that metacognitive skills bridge the gap between theoretical knowledge and its application in real-world scenarios. The structured intervention, focusing on planning, monitoring, and evaluating strategies, appears to have empowered students to approach problem-solving tasks more systematically.

The improvement in students' self-reported metacognitive awareness, as reflected in the MAI scores, indicates that the intervention successfully promoted self-regulated learning habits. These findings mirror the results of Dignath and Büttner (2008), who found that interventions targeting self-regulated learning components, including metacognitive strategies, led to significant improvements in students' academic achievement. The increase in self-monitoring and self-evaluation practices suggests that students became more reflective and intentional in their learning.

The qualitative data from student reflection journals provided deeper insights into the impact of the intervention on student behaviors and attitudes. Many students expressed that they

became more proactive in planning and checking their understanding before, during, and after solving problems. This finding resonates with Zimmerman's (2008) assertion that metacognitive training enhances learners' motivation and engagement, contributing to a more active learning disposition.

Another key finding is that students in the experimental group developed greater perseverance and resilience when facing challenging tasks. This behavioral shift is critical, as problem-solving often involves dealing with ambiguity and failure. Consistent with research by Teng (2019), students who received metacognitive training demonstrated increased persistence and the ability to reframe failure as a learning opportunity, thereby fostering a growth mindset.

The statistical significance confirmed by ANCOVA results strengthens the case for integrating metacognitive instruction in secondary school curricula. The moderate to large effect size indicates that the training had a meaningful impact on student learning outcomes, extending beyond superficial gains. Darling-Hammond et al. (2020) highlight that in the context of 21st-century education, problem-solving and critical thinking skills are indispensable for student success in higher education and the global workforce, reinforcing the value of metacognitive interventions.

When compared to research conducted in higher education settings, such as Bannert and Mengelkamp (2013), who found that metacognitive prompts improved performance in hypermedia learning environments, this study demonstrates that similar benefits are achievable at the secondary school level. This suggests that metacognitive training is adaptable across various educational stages and learning contexts, confirming its universality and relevance.

Furthermore, the reflections collected from students indicate an increased sense of autonomy and ownership of learning processes. This is in line with the findings of Schraw et al. (2006), who emphasized that metacognitive awareness encourages students to take control of their learning, fostering self-directed learning habits. In the long term, this autonomy can contribute to improved academic resilience and self-efficacy.

Despite these positive findings, the study also revealed certain challenges faced by students, such as the initial difficulty in adopting metacognitive strategies. This is consistent with Veenman et al. (2006), who noted that metacognitive training requires sustained practice and reinforcement for students to internalize and consistently apply the strategies across different subject areas.

Moreover, it is worth noting that the students in the experimental group reported an increased awareness of their cognitive strengths and weaknesses. This metacognitive insight enabled them to tailor their problem-solving approaches to their individual learning styles, supporting Dignath and Büttner's (2008) argument that metacognitive instruction can lead to more personalized and effective learning strategies.

Lastly, the findings of this study contribute to the broader discourse on educational interventions designed to enhance 21st-century competencies. By demonstrating the direct link between metacognitive awareness and improved problem-solving skills, this research underscores the need for curriculum designers and policymakers to embed metacognitive instruction into secondary education programs. Such efforts will ensure that students are equipped with the cognitive tools necessary for lifelong learning and adaptability in an increasingly complex world (Darling-Hammond et al., 2020).

Conclusion (خاتمة)

This study demonstrates that metacognitive training has a significant positive impact on enhancing secondary school students' problem-solving skills. The results from quantitative data (pre-test and post-test scores) and qualitative data (reflection journals and metacognitive awareness questionnaires) consistently show that students who participated in metacognitive training exhibited better planning, monitoring, and evaluation strategies when solving complex problems. The findings indicate that metacognitive instruction not only improves students' cognitive processing but also fosters self-regulated learning habits that are essential for academic success in the digital era.

Moreover, the integration of metacognitive strategies into daily learning practices has shown to promote greater student autonomy, persistence, and reflective thinking. These outcomes suggest that embedding metacognitive training in secondary school curricula can be an effective approach to address the persistent problem of low problem-solving skills among students. Future research may explore long-term effects of metacognitive interventions and how they can be adapted across different cultural and educational settings to further enhance students' critical thinking and adaptive learning abilities.

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