EduLine: Journal of Education and Learning Innovation *ISSN: 2775-6173 (online)*
Vol. 3 No. 1 (2023)
https://doi.org/10.35877/454RI.eduline1702

The Correlation between Metacognitive and Problem-Solving Skills among Science Students

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Abstract

This study aims to investigate the correlation between metacognitive and problem-solving skills among science students. The sample consisted of 32 students from departement of science education in Indonesia. This type of research is quantitative with the *Pearson Product Moment Correlation* method. The data were collected using a problem-solving test and a metacognitive awareness inventory (MAI). Technique of analyzing data uses the Pearson'correlation test by using IBM SPSS Statistics 26. Result of this research is there is a significant linear relationship between metacognitive and problem solving skills as the value of deviation from linearity is 0.225, which is greater than 0.05. The obtained Pearson correlation value of 0.382* also indicates a strong positive correlation (+0.382*) and a significant correlation (0.031<0.05) between the two variables. As a conclussion, there is a correlation between metacognitive and problem solving skills among science students. Further analysis revealed that students with higher metacognitive skills tended to perform better in problem-solving tasks, indicating the importance of metacognitive skills in science problem-solving. These findings suggest that promoting metacognitive awareness could enhance students' problem-solving abilities, and support the integration of metacognitive strategies in science education. These findings highlight the importance of promoting metacognitive awareness in learning process to enhance problem-solving skills by using innovative learning strategies.
Keywords: problem solving, metacognitive, science.

1. Introduction

Metacognitive and problem solving are some of the skills suggested to be possessed by every student in the 21st century to be able to thrive amidst the advancements in science and technology. Problem-solving skills can be interpreted as an individual's ability to identify, analyze, and solve problems (Snyder & Snyder, 2008). Meanwhile, metacognition is an individual's ability to recognize, understand, and regulate their own thinking by declaring, procedure and conditioning their knowledge (Schraw & Dennison, 1994). Problem-solving and metacognitive skills are very important in education because both are related to an individual's ability to learn and achieve academic goals (Gok, 2010). Problem-solving skills enable individuals to solve problems in various fields, while metacognition enables individuals to monitor their own thinking and learning to improve their learning performance (Hollingworth & McLoughlin, 2001).

Problem-solving and metacognitive skills are essential for students in learning science because they enable students to actively engage with scientific concepts and phenomena (Akben, 2020). Through problem-solving, students learn how to apply scientific principles and concepts to real-world problems, which promotes their critical thinking and decision-making abilities. Additionally, metacognitive skills help students monitor their own learning progress, identify areas of difficulty, and adjust their learning strategies to improve their understanding of scientific concepts (Rickey & Stacy, 2000). By developing problem-solving and metacognitive skills, students are better equipped to succeed in science education and pursue careers in science-related fields (Salonen et al., 2017). Moreover, problem-solving and metacognitive skills are essential for lifelong learning and personal development (Dunlap & Grabinger, 2003), as they enable individuals to identify and solve problems in various contexts and improve their learning strategies. Therefore, promoting problem-solving and metacognitive skills in science education can benefit students both academically and personally.

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Based on observation result in science classrooms, problems in science learning arise when students have difficulty solving the complex problems. One of the causes is the weakness in students' thinking strategy skills. When students do not have good thinking strategy skills, they tend to have difficulty identifying problems and determining effective ways to solve the tasks. In addition, students may also have difficulty understanding abstract and hierarchical scientific concepts. So they cannot connect theory with its application in daily life. This affects the inability of students to make a strong connection between theoretical knowledge and its application in real-world situations, resulting in low understanding and learning outcomes in science. Therefore, it is important for educators to help students develop proper thinking strategy (metacognitive) skill, so they can overcome problems and produce innovative solutions in science learning.

This research attempts to prove whether there is a relationship between thinking strategies (metacognitive) and problem-solving abilities in students. Students' metacognitive are facilitated by problem-based learning strategy to improve students' problem-solving quality in chemical compound materials. There is still a lack of research on the correlation between problem-solving and metacognitive abilities, particularly in the context of science education. Therefore, this article aims to deepen our understanding of the correlation between problem-solving and metacognitive abilities and its implications in the context of science education.

2. Literature Review

2.1 Metacognitive

According to Flavell (1979), metacognition refers to an individual's thinking ability to manage their thinking process and outcomes, and actively monitor and regulate their cognitive processes. Meanwhile Schraw & Dennison (1994) explains that metacognition encompasses awareness and knowledge of one's cognition, including declarative knowledge, procedural knowledge, and conditional knowledge for problem-solving. Additionally, metacognitive awareness involves prediction, planning, monitoring, and evaluation skills (Schraw, 1998). Rompayom et al., (2010) stated that developing metacognitive ability is crucial for science learning because it plays a critical role in problem-solving, and students can become better problem solvers if they possess metacognitive knowledge. Marzano' taxonomy includes metacognitive ability in the metacognitive system, which is assumed to be higher than the cognitive system. (Marzano, 2001) also divides thinking abilities into three systems: the self-system, the metacognitive system, and the cognitive system, which work together. When facing a problem, the self-system decides whether to accept the challenge or choose another activity. Meanwhile, the metacognitive system sets goals and monitors the progress of problem-solving. It regulates all other systems and makes decisions about which information is needed and which cognitive processes are most appropriate for achieving the goal.

2.2 Problem Solving

According to Greenstein (2012), problem-solving is one of the four thinking skills that students should possess in the 21st century, as an individual's ability to solve problems accurately and quickly is a key indicator of intelligence. The primary aim of problem-solving is to train the thinking process and use the results of thinking to find solutions. Bloom places problem-solving ability at the concept analysis level (C4) as one of the operational verbs in high-level cognitive ability. Similarly Marzano & Kendall (2008) view problem-solving ability as a thinking skill that can be acquired once students have built, understood, analyzed, and utilized their knowledge. In Marzano's taxonomy, problem-solving ability is categorized under knowledge utilization. Problem-solving is a high cognitive activity that requires the skill to analyze information and its relationships to draw logical conclusions. Generally, problem-solving involves formulating a new solution based on previously learned knowledge. According to Jonassen & Hung (2008), problem-solving demands the ability to identify causal relationships among various concepts, leading to the discovery of the key to unlocking the problem.

3. Research Method and Materials

This research uses a quantitative method to examine the relationship between metacognitive and problem-solving ability among 32 science students from Universitas Negeri Malang. The sample is taken using purposive sampling technique to ensure that all respondents have characteristics relevant to the research objectives. The research instruments used are the Metacognitive Awareness Inventory (MAI) and Problem-solving test questions. Data obtained from both instruments are analyzed using statistical analysis techniques, including normality test, linearity test, and correlation test. The correlation test used is the Pearson Product-Moment Correlation method and it performed using IBM SPSS Statistics version 26 software.

The design of the study utilized the Product Moment correlation design to examine the relationship between two variables. Specifically, the focus of the study was to determine the correlation between metacognition ability and problem-solving ability. The Product Moment correlation is an appropriate method to determine the strength and direction of the relationship between two variables, and it was selected for its ability to provide an accurate representation of the correlation between the variables. The diagram in Figure 1 illustrates the relationship between the two variables in the study. Where X is Metacognitive, Y is Problem Solving and r_{xy} is for Relation between them.

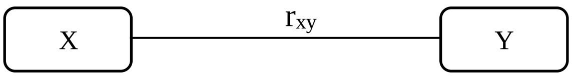

Figure 1. Relation between Metacognitive and Problem Solving

4. Results and Discussion

4.1 Normality Test

Table 1. Data of Normality Test Results.

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Problem solving	.090	32	.200*	.978	32	**.731**
Metacognitive	.120	32	.200*	.963	32	**.322**

The results of the normality test for the metacognitive and problem-solving data in table 1 indicate a significance value of 0.322 and 0.731, respectively. Since both values are higher than the significance value of 0.05, it can be concluded that both datasets have a normal distribution and are appropriate for subsequent tests, such as linearity and correlation tests.

4.2 Linearity Test

Table 2. Data of Linearity Test Results.

ANOVA Table							
			Sum of Squares	df	Mean Square	F	Sig.
Metacognitive * Problem solving	Between Groups	(Combined)	1754.175	15	116.945	1.796	.128
		Linearity	407.315	1	407.315	6.256	.024
		Deviation from Linearity	1346.860	14	96.204	1.478	**.225**
	Within Groups		1041.700	16	65.106		
	Total		2795.875	32			

a. Lilliefors Significance Correction

In the table 2, a deviation from linearity value of 0.225 was obtained. Because the deviation value of 0.225 is greater than the significance value of 0.05, it concluded that there is a significant linear relationship between the metacognitive ability variable and problem-solving.

4.3 Pearson' Correlation Test

To interpret the Pearson correlation output in SPSS, there are three stages to consider. The first stage involves examining the strength of the relationship between the variables. The output shows a coefficient of 0.382*, indicating a strong correlation between the Metacognitive and Problem Solving variables. The asterisk (*) suggests that this correlation is significant at the 5% or 0.05 level. The second stage involves examining the direction of the relationship between the variables. In this case, the correlation coefficient is positive, specifically 0.382, which means that the two variables are positively related. An increase in Metacognitive scores will result in an increase in Problem Solving scores. The final stage involves determining the significance of the relationship. In this case, the significance value or Sig. (2-tailed) is 0.031, which is less than 0.05, indicating a significant relationship between Metacognitive ability and Problem solving. In conclusion, at a significance level of 5%, there is a strong positive correlation of 0.382 between Metacognitive and Problem Solving scores. Therefore, an improvement in Metacognitive scores will lead to an increase in Problem Solving scores.

Table 3. Data of Correlations Test Results.

Correlations			
		Metacognitive	Problem solving
Metacognitive	Pearson Correlation	1	**.382***
	Sig. (2-tailed)		**.031**
	N	32	32
Problem solving	Pearson Correlation	**.382***	1
	Sig. (2-tailed)	**.031**	
	N	32	32

*. Correlation is significant at the 0.05 level (2-tailed).

The results of this study indicate a strong correlation between metacognitive and problem-solving skills among science students. This finding is consistent with previous research that has also demonstrated a significant relationship between these two constructs. As mentioned, there is relationship between metacognition and problem solving in mathematics understanding (Güner & Erbay, 2021) and (Toraman et al., 2020). Swanson (1992) in his research, found that there is relationship between metacognition and problem solving in gifted children. It suggests that students who are more aware of their own thinking processes are better able to engage in problem-solving activities effectively. These findings underscore the importance of developing metacognitive skills in students, particularly in the context of science education.

To enhance students' metacognitive skills, problem-based learning (PBL) could be an effective strategy. PBL is a student-centered teaching approach that emphasizes the use of real-world problems to engage students in critical thinking, collaboration, and problem-solving. This approach allows students to practice metacognitive skills as they monitor and reflect on their own learning processes. Research has shown that PBL can be an effective method for promoting the development of metacognitive skills among students, including in the context of science education (Downing et al., 2011), (Pratama, 2018) and (Haryani et al., 2018).

In light of the findings of this study, educators should consider incorporating PBL strategies into their science curricula to promote the development of students' metacognitive skills. This could involve designing real-world problems that challenge students to use higher-order thinking skills, encouraging them to reflect on their problem-solving strategies and identify areas for improvement (Hmelo & Ferrari, 1997). Furthermore, teachers could provide opportunities for students to engage in collaborative problem-solving activities, allowing them to learn from each other and practice communication and teamwork skills. Overall, these strategies could help students become more effective problem-solvers and better equipped to succeed in science and other academic domains.

5. Conclusion

In conclusion, our study has provided evidence of a positive correlation between metacognitive and problem-solving skills among science students. The findings indicate that students with higher metacognitive skills tend to have better problem-solving abilities, which supports the idea that both skills are important for science academic success. Teachers can incorporate activities that promote metacognitive and problem-solving thinking into their lessons, such as providing opportunities for students to reflect on their own thinking processes and encouraging them to think critically and creatively to solve problems by using problem based learning.

However, the study has some limitations that should be taken into consideration. Firstly, the study was limited to a sample of science students in Indonesia, which may limit the generalizability of the findings to other populations. Future research should aim to replicate these findings using a larger and more diverse sample and employing more objective measures of problem-solving and metacognitive skills.

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