Developing Metacognitive Skills Through N03R Learning

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Abstract. Students require metacognitive skills to reflect on what is being done, what is required in completing assignments, and selecting and implementing learning strategies that promote learning success. The development of metacognitive skills requires creative thinking and a systematic process in learning to solve mathematical problems, which has not been implemented optimally. This study aims to determine students' metacognitive skills through NO3R learning in solving mathematical problems. This study uses sequential exploratory mixed methods. Data was collected through tests, observation techniques, interviews, and documentation. The research subjects were 31 students who were asked to work on geometry problems. The researchers analyzed each student's work based on the NO3R learning stages. Furthermore, to clarify answers and explore students' metacognitive skills, in-depth observations and interviews were performed. The results showed that students' metacognitive skills in solving math problems were on high criteria. NO3R learning is effective for developing students' metacognitive skills. Metacognitive skills can be taught to students to develop their thinking so that their learning outcomes are better.

Key words: Metacognitive skills; Solving Mathematical Problems; NO3R Learning.

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INTRODUCTION

Students must be trained in problem-solving processes through mathematical thinking activities so that they can solve life-related problems that are not typically routine. Without problem-solving, students learn only how to compute and not why and when to use math skills (Browder, 2017). Problem-solving is what you do when you do not know what to do (Anilan, 2019). Students completed a comprehensive metacognitive on the creative thinking learning path, from planning to evaluation, prior knowledge formation, and the selection of creative ideas to action (Fauzi, 2019). It takes the ability to choose the right strategy to use mathematical tools (concepts, algorithms, and procedures) that are owned in the problem-solving process (Zahid, 2020). Problem-solving skills, critical thinking, and analytical skills are very much needed by students in learning mathematics. The ability to use logical thinking and thinking skills plays an important role in students' academic success, understanding scientific concepts and the nature of science (Aiym, 2022).

Skills for students are critical in developing the ability to solve problems that have implications for independence, autonomy, and self-regulation. Students must also have other skills in order to obtain and use information in situations that are constantly changing, uncertain, and competitive (Dochy, 2001; Hannula, 2004). Because metacognitive thinking skills play an important role in learning success, it is critical to investigate metacognitive activities to determine how students are taught to apply cognitive resources through metacognitive control (Livingston, 2003). Metacognitive skills are needed to understand how the task is carried out (Corebima, 2009). Lack of metacognitive ability also has an impact on students' less systematic thinking (Erlin, 2021). Metacognitive self-regulation gives a high contribution to critical thinking skills (Gurcay, 2018). Metacognitive skills influence students' thinking, cognitive learning outcomes, and ability to remember what they have learned (retention).

According to Eggen and Kauchak (1996), developing metacognitive skills in students is a valuable educational goal because these skills can help students become self-regulated learners, i.e. students who are responsible for their own learning progress and adapt their learning strategies to meet task demands. The goal of developing metacognitive skills is for students to understand how tasks are completed so that they can perform better in their profession (Feyzi, 2003). Metacognitive skills refer to a person's knowledge and awareness of their own cognitive activity or anything related to their cognitive activity (Schoenfeld, 1992; Livingston, 2003). Metacognitive skills are methods for learning, studying, or solving problems (Slavin, 2006). Metacognitive thinking skills are a general concept of skills that not only help current knowledge to be remembered and understood but also help them to be organized and used (Doganay, 2007). Metacognitive skills are conceptualized as a set of interrelated competencies for learning and thinking, and include many of the skills needed for active learning, critical thinking, reflective judgment, problem-solving, and decision making (Dawson, 2008). Students with metacognitive skills are more responsible, independent, and self-regulated (Listiana, 2016; Sonowal and Kalita, 2017; Coskum, 2018). Students must be able to monitor, assess, and modify learning through their own metacognitive processes, so that they can develop the necessary knowledge and improve their learning (Mendes, 2020).

According to Cooper (2008), metacognitive skills are predictive skills that will be fulfilled when students understand the problem and what is known and asked in questions involving students can plan the steps that must be completed. Planning skills focus on students' ability to convert story problems into mathematical models and determine the best strategy for solving math problems. Monitoring skills focus on the application or use of appropriate formulas in solving problems and applying appropriate concepts. Evaluation skills focus on accuracy in the calculation process and double-checking answers. Metacognitive skills require metacognitive strategies to teach them. Metacognitive strategies are routines that represent specific mental processing actions that are carried out as part of a complex process in order to achieve goals such as understanding what has been learned (Hacker, 2009). A teacher's metacognitive skills depend on procedural knowledge or actual regulation and control in learning activities (Van der Stel, 2014). Planning, monitoring, and evaluating the learning process are some of the skills that distinguish the metacognitive process (Martinez, 2018). Students will learn what to do and how to do it with metacognitive strategy training, but to increase self-efficacy for self-regulation, they will need many repeated successful experiences, encouragement of benefits, and demonstration of using successful strategies (Adel, 2020).

In this study, the learning strategy used to develop metacognitive skills in solving mathematical problems is the NO3R learning model (Rokhman 2021). NO3R learning model is a learning procedure to help students think systematically by conducting information seeking activities related to mathematical problems through networking; thoroughly observing the problem; analyzing information, making assumptions, creating patterns, and coming up with solutions to problems (be open-minded); evaluating problem-solving results, interpreting problem-solving outcomes (overview); and recognizing the validity and legality of the problem-solving results obtained, regardless of whether they are true or false.

The NO3R learning model has been validated by educational experts and practitioners with an average score (Va) of 4.61, which falls within the $4 \leq Va < 5$ range and meets the very valid criteria. The assessment of content validity yielded an average score (Va) of 4.78, which met the very valid criteria at $4 \leq Va < 5$. Meanwhile, the construct validity assessment yielded an average score (Va) of 4.48, which meets the very valid criteria at $4 \leq Va < 5$. The criteria for the validity of the NO3R learning model based on the percentage of validator perceptions obtained 92.24 percent, which is in the interval of $84\% \leq x \leq 100\%$, meets the criteria for very feasible use in learning.

The objective of this study is to assess students' metacognitive skills in solving mathematical problems using NO3R learning.

METHODS

The research subjects were 31 students of class XII at SMA Negeri 1 Salem, Indonesia. Students were given assignments to solve mathematical problems in geometry based on the NO3R learning stages. Researchers corrected and analyzed each student's response in order to classify and determine the achievement of students' metacognitive skills in the areas of prediction, planning, monitoring, and evaluation. Mixed Methods Sequential Exploratory was used in this study. Tests, observation techniques, interviews, and documentation were used to collect data. The metacognitive skills observation sheet instrument was validated by experts and education practitioners with an average score (Va) of 4.63, which is in the range $4 \leq Va < 5$ with very valid criteria, and the percentage of validator perceptions is 92.65, which is in the interval range of $84\% \leq x \leq 100\%$ with very good criteria. In-depth interviews were conducted after analyzing the results of students' answers in order to clarify students' metacognitive skills from each aspect of metacognitive skills in solving mathematical problems.

The assessment rubric to determine the criteria for achieving students' metacognitive skills is as shown in Table 1.

Table 1. Criteria for Achievement of Metacognitive Skills

Average Score	Achievements (%)	Criteria
4.2 ≤ Va < 5	84 ≤ *x* ≤ 100	Very good/Very High
3.4 ≤ Va < 4.2	68 ≤ *x* < 83	Good/High
2.6 ≤ Va < 3.4	52 ≤ *x* < 67	Fairly Good/Medium
1.8 ≤ Va < 2.6	36 ≤ *x* < 51	Not Good/Low
1 ≤ Va < 1.8	20 ≤ *x* < 35	Poor/Very Low

Note: Va is Average score, x is Achievement of metacognitive skills

RESULTS AND DISCUSSION

The results of observations on students' metacognitive skills on aspects of predictive skills, planning skills, monitoring skills, and evaluation skills are as shown in Table 2.

Table 2. Metacognitive Skills Observation Results

Aspects of Metacognitive skills	Descriptor	Indicator	Vr	Va	Vr %	Va %
Prediction Skills	Understanding Problems	Students attempt to understand a given math task or problem before attempting to solve it.	3.77	3.83	75.48	76.65
		Students believe that their prior knowledge is extremely beneficial in understanding mathematical material.	3.84		76.77	
		Students believe that understanding the material is extremely beneficial in solving math problems.	4.26		85.16	
	Understanding what is known and what is being asked in the question.	Students make an effort to pay attention to what is known and asked in math problems.	3.68		73.55	
		Students use a summary of what is known and asked, as well as their knowledge and concepts, to solve the given problem.	3.61		72.26	
Planning skills	Capable of converting story problems into mathematical models	Students convert the provided questions into mathematical statements.	2.87	3.34	57.42	66.88
	Capable of determining the best strategy for	Students attempt to use prior knowledge to plan the solution to a given mathematical problem.	3.90		78.06	

	solving math problems	Students plan the steps for solving a mathematical problem by using the right strategy before starting to work on it	3.26		65.16	
Monitoring skills	Capable of applying or utilizing appropriate formulas or procedures in problem-solving	Students solve problems by applying or employing appropriate formulas or procedures.	3.61	3.54	72.26	70.75
		Students follow the steps that have been laid out in order to solve a given math problem.	3.52		70.32	
	Capable of applying concepts correctly	Students correctly apply the mathematical concepts used.	3.48		69.68	
Evaluation skills	Accuracy in the calculation process	Students have control over the use of symbols, notations, and mathematical calculations when solving math problems.	3.06	3.50	61.29	69.94
		whether the outcomes of their mathematics learning are in line with the set targets	3.32		66.45	
	Rechecking answers	Students double-check to ensure that the answers obtained are correct.	4.03		80.65	
		Students double-check the accuracy of everything they know and have been asked about, including concepts, explanations, mathematical terms, and symbols used to solve mathematical problems.	3.48		69.68	
		Students consider simpler alternative solutions to solve the given problem.	3.58		71.61	
		Average	3.58		71.61	

Vr = The average of each metacognitive skill indicator, Va = The average of each aspect of metacognitive skills

Based on Table 3, the average score of students' metacognitive skills is 3.58 in the range of 3.4 ≤ Va < 4.2 which meets the criteria well. Meanwhile, the percentage of students' metacognitive skill achievement is 71.61% in the range of 68% ≤ x < 83% which meets the high criteria. The criteria for each aspect of metacognitive skills and the percentage of students' achievement of metacognitive skills are as follows: the prediction aspect is 3.83 (good) and 76.65% (high); planning aspect obtained 3.34 (good enough) and 66.88% (moderate); monitoring aspect obtained 3.54 (good) and 70.75% (high); and the evaluation aspect obtained 3.50 (good) and 69.94% (high).

The use of the NO3R learning model in mathematics learning is said to have met the effective criteria if more than 75% of students obtain learning outcomes in solving math problems above 68 (the minimum criteria for completeness set) and more than 75% of students have metacognitive skills in solving mathematical problems at least on good criteria. The One sample t-test statistical test is used to determine whether the learning outcomes of the ability to solve mathematical problems meet the minimum completeness criteria of 68 by comparing parameter values that are significantly different from the sample average value. A proportion test was also performed to test the hypothesis that the percentage of students who completed their learning was greater than or equal to 75% of the total number of students. The normality test was performed first, followed by the completeness and proportion tests. The SPSS application was used to analyze the data in this study.

Table 3 shows the results of the Tests of Normality.

Table 3. Tests of Normality
Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
KPM	.158	31	.048	.946	31	.120

a. Lilliefors Significance Correction

Based on the results of the Tests of Normality in Table 4, it can be seen that sig. from the data is 0.120 > 0.05 (Shapiro-Wilk) so that Ho is accepted, which means that the variable data on the learning outcomes of students' mathematical problem-solving abilities are normally distributed.

The completeness test was used to determine the student's individual and classical mastery achievement in mathematics problems using the NO3R learning model. Individual completeness test was used to determine whether or not the average learning outcomes of students' mathematical problem-solving abilities exceed 68. A one-sided test was used for the class average completeness test. The proposed hypotheses are shown below.

H_0 : $\mu \leq 68$ (Average learning outcomes of students' mathematical problem-solving skills using the NO3R learning model ≤ 6868)

Ha : $\mu > 68$ (Average learning outcomes of students' mathematical problem-solving skills using the NO3R learning model > 68).

For decision making criteria, reject H0 if $t_{count} \geq t_{critical}$ or if the sig. value is sig. 2-tailed ≤ ∝ with dk = (n-1) and error level (significance level) ∝ = 0.05 = 5%.

The output of the One-Sample Test for the completeness test is as shown in Table 4.

Table 4. Completeness Test
One-Sample Test

	Test Value = 68					
					95% Confidence Interval of the Difference	
	T	Df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Problem-solving skill	8.587	30	.000	8.742	6.66	10.82

Based on the results of the one-sample completeness test in Table 5, the value of sig. (2-tailed) is

0

H_0 : $\pi \leq 75\%$ (The proportion of students in learning using the NO3R learning model who achieves the minimum completeness criteria has not exceeded or equal to 75%)

Ha : $\pi > 75\%$ (The proportion of students in learning using the NO3R learning model who achieves the minimum completeness criteria has exceeded 75%).

.000 < 0.05, indicating that H0 is rejected. This means that the NO3R learning model's average learning outcomes for students' mathematical problem-solving abilities are > 68.

The proportion test was used to test the hypothesis that the percentage of student learning completeness is more than or equal to 75% of the number of students in the class with a significant level = 0.05. The hypotheses for testing the proportion of completeness with an error level of 0.05 are as follows.

The results of the analysis of completeness proportion tests are as shown in Table 5.

Table 5. Completeness Proportion Test
Binomial Test

		Category	N	Observed Prop.	Test Prop.	Asymp. Sig. (1-tailed)
Problem-solving skill	Group 1	<= 68	4	.13	.75	.000[a,b]
	Group 2	> 68	27	.87		
	Total		31	1.00		

a. Alternative hypothesis states that the proportion of cases in the first group < .75.

b. Based on Z Approximation.

Based on the completeness proportion test results in Table 6, the value of sig. (1-tailed) is 0.000 0.05, so H0 is rejected. This means that the proportion of students in learning using the NO3R learning model who achieves the minimum completeness criteria of 68 has exceeded 75%. Based on observations of NO3R learning implementation, it was concluded that students are able to find and integrate information through networks (networking), are able to observe what is known and asked, make additional questions to solve problems (observing), are able to consider ideas with an open mind (openminded), are able to review and infer from the solutions found (overview), and are able to acknowledge the truth and validity of the solution (recognize). Based on the results of the data analysis described above, it can be concluded that the NO3R learning model is effective in developing students' metacognitive skills in solving math problems.

After analyzing students' responses, in-depth interviews were conducted to clarify answers and explore students' metacognitive skills in solving math problems based on the NO3R learning stages. Interviews were conducted with 6 students where 2 students represented the low group (AD and OH), 2 students represented the medium group (EN and DS), and 2 students represented the high group (TZ and RW). The summary of interview results related to students' metacognitive skills in solving math problems using NO3R learning is shown in Table 6.

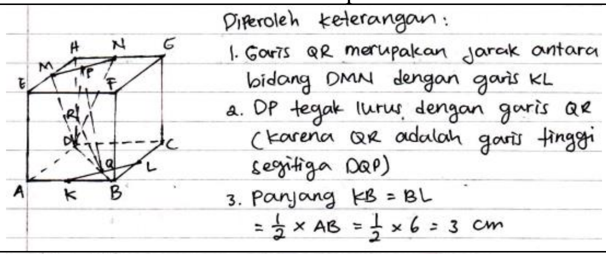
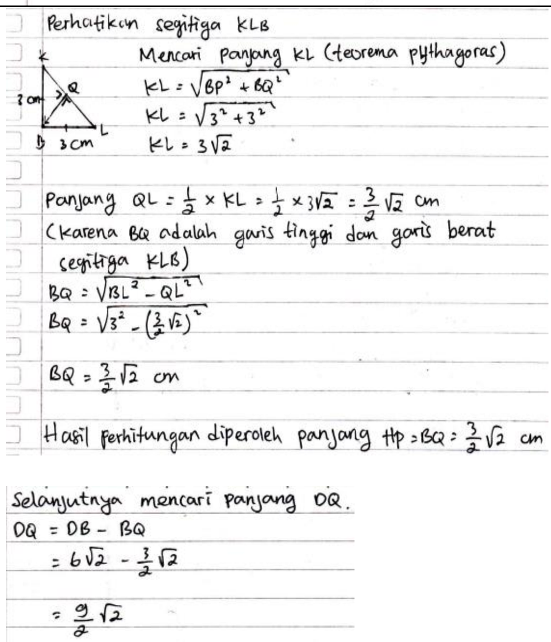
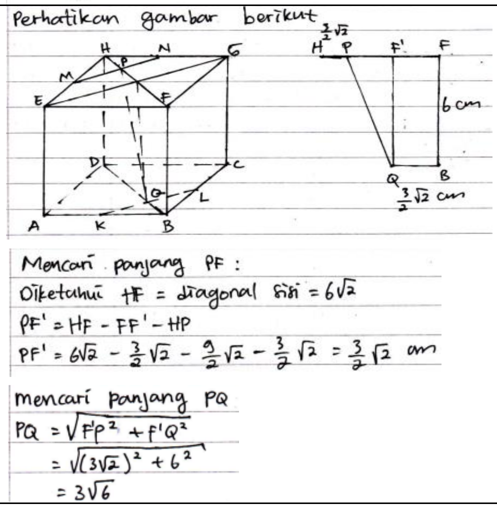
Table 6. Summary of Interview Results

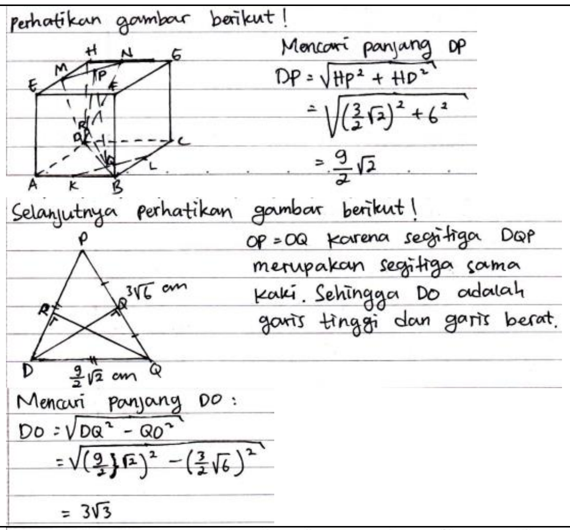
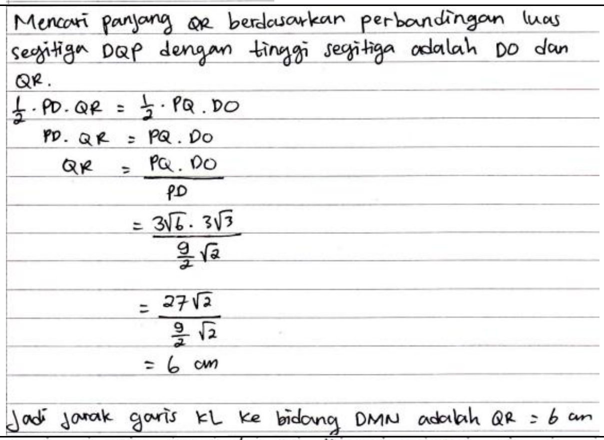
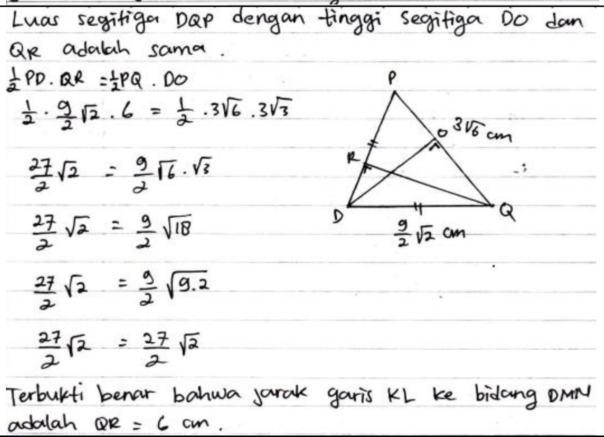
Participants	Interview Summary
AD	Students have been unable to understand a given mathematical task or problem before attempting to solve it. Students have been unable to comprehend the problem by resurrecting old information and learning experiences.
OH	Students are still attempting to understand the problem by examining what is known and asked in math problems. Students are still attempting to devise or consider a problem-solving strategy.
EN	Students can understand the problem quite well by using a summary of what is known and asked, as well as the knowledge and concepts they have to solve the given problem. Students are quite capable of converting given problems into mathematical statements.
DS	Students have quite good control over the use of symbols, notations, and mathematical calculations when solving mathematical problems.

TZ	Students are able to understand the problem and plan the steps for solving a mathematical problem using the right strategy before starting to work on it. Students are able to apply or use the right formula in solving problems.
RW	Students are able to use the planned steps to solve a given mathematical problem. Students can think of alternative solutions that are easier to solve a given problem.

Based on the NO3R learning stages, the following is an example of displaying student work in a complete and correct manner. Students work on the following assignments:

A cube ABCD.EFGH has a side length of 6 cm. Point K, point L, point M, and point N are the midpoints of edges AB, BC, EH, and GH, respectively. Calculate the distance from the KL line to the DMN plane.

Student activities according to NO3R stages	Students' responses
Networking 1. Students use networks such as the internet, textbooks, discussions, modules, student worksheets, and other learning resources to search, collect, and compile information. 2. Students also integrate the information they have learned.	
Observing 1. Students identify and write down what they know and what they are asked in the form of notation/graphics/pictures/mathematical models or mathematical statements. 2. To solve the problem, students create help/additional questions from the presented math problems.	
Openminded 1. Students use their minds to figure out which method or procedure to use to solve the problem. 2. Furthermore, students carry out the process of solving the problem according to the chosen method or procedure.	

<table>
<tr><td></td><td>
</td></tr>
<tr><td>Overview
1. Students double-check their problem-solving outcomes.
2. Furthermore, students draw conclusions from the results of problem-solving.</td><td>
</td></tr>
<tr><td>Recognize
1. Students recognize the truth value of problem-solving outcomes.
2. Students accept the validity and legality of the problem-solving outcomes.</td><td>
</td></tr>
</table>

The findings of this study show that students' achievement in metacognitive skills to solve math problems using the NO3R learning model on high criteria is marked by students having predictive skills, planning skills, monitoring skills, and evaluation skills. These findings support the findings of previous studies (Schraw, 2006; Cooper, 2008; Martins, 2018; Fauzi, 2019; Mendes, 2020; Erlin, 2021) that the factors that influence metacognitive thinking skills are identifying the task they are working on, making appropriate arrangements, monitoring the progress of their work, evaluating progress, and predicting the results to be obtained.

CONCLUSION

Students' metacognitive skills in solving mathematical problems based on the NO3R learning stages in general are on high criteria. Prediction skills are achieved on the high criteria, where students are able to understand problems and understand what is known and asked about math problems by conducting information seeking activities through networking and observing. However, the achievement of planning skills is on the moderate criteria, with a small number of students indicating that they have not been able to transform mathematical problems into mathematical models or determine the best strategy for solving mathematical problems. The achievement of monitoring skills on the high criteria, where students are able to apply formulas or procedures to solve problems and apply concepts used appropriately by being open-minded to new ideas. Meanwhile, the achievement of evaluation skills is on the high criteria, with students being able to perform accuracy in the calculation process and re-examine the answers obtained by strengthening to acknowledge the truth of the results of problem-solving is valid or legal (recognize).

The NO3R learning model is effective in developing students' metacognitive skills in math problem-solving. Students can be taught metacognitive skills to help them develop their thinking and improve their learning outcomes.

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