

Impact of Heuristic Strategy on Students' Mathematics Ability in High Order Thinking

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ABSTRACT

The purpose of this study is to determine the impact of heuristic strategy on students' mathematical abilities in high order thinking. This descriptive research uses a correlation design. The population of this study were all second-grade public and private high school students representing schools from eight districts in North Sumatra province, and samples (N = 257) were taken randomly. Based on linear regression analysis through analysis of variance (ANOVA) results obtained that heuristic strategy has a very strong influence on students' mathematical abilities in high order thinking, and partially heuristic strategies affect students' ability in (1) understanding of concepts, (2) creativity, (3) mathematical communication, (4) problem solving, and (5) reasoning ability.

Keywords: heuristic strategy, students' mathematical abilities, HOT

INTRODUCTION

The ability of students is one of the main factors in mathematics education, because it can be used to determine the success of the implementation and success of students absorbing learning material. Currently education in Indonesia, is using the 2013 curriculum with the target of students having mathematical abilities with high order thinking (HOT) in accordance with PISA standards. However, the expected results have not been achieved well, where the average national mathematics test scores decreased from the previous year (Effendy, 2018). The importance is HOT in learning mathematics so students can master mathematics well (Amalia, 2013). The results showed that there was a significant relationship between HOT and student learning outcomes (Jailani, 2017; Tanujaya, 2017; Widodo & Kadarwati, 2013).

Some of the main factors that influence HOT students in mathematics are seen from external factors such as unfavorable learning processes (Al-Agili, 2012; Heleni, 2009), teachers are not good at choosing learning strategies (Margaret, 2015), the problem is not in accordance with the ability of students (Tambunan, 2016, 2018), the teacher does not carry out his role as a motivator (Tambunan, 2018), and can increase HOT students (Kurniati, 2016; Prasetyani, 2016; Saragih & Napitupulu, 2015; Ulfa, 2013). Therefore, the learning approach becomes an important factor in mathematics learning so that students have HOT abilities. Many strategies have been developed by education experts to be used in mathematics learning, one of which is the heuristic strategy. This research question is how is the impact of heuristic strategy on students' mathematical abilities in high order thinking? The purpose of this study is to determine the effect of heuristic strategy on students' mathematical abilities in high order thinking.

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HEURISTIC STRATEGY

Strategy is an effort activity, design, approach, and a series of steps taken by the teacher to achieve an educational goal (Hamdani, 2011; Hamzah & Muhlisrarini, 2014; Ngalimun, 2014; Riyanto, 2010; Yamin, 2013). The implementation of learning strategies can be given some important heuristics to make it easier for students to understand the subject matter. Heuristics as an adjective, means “serving to discover” (Polya, 1973). Heuristics help to find solutions (Webster’s, 1985). Heuristics are general suggestions that help an individual to make progress toward its solution (Shoenfeld, 1985). Heuristics is a guide that can lead to problem solvers to find a solution to the problem (Tambunan, 2014).

Studying mathematics means learning to solve problems, both problems related to everyday problems as well as solving mathematical problems themselves. Problems in mathematics are questions in mathematics to be solved (Baroody, 1993; James, 1976). Polya (1973) states four stages in problem solving learning, namely (1) understanding the problem, (2) planning a solution, (3) completing the model, and (4) checking again. A strategy by giving a heuristic in the form of statements, commands or questions to all four stages and problem solving steps is called a heuristic strategy (Tambunan, 1999).

The heuristic strategy in learning mathematics using these four stages can be summarized as follows. The first stage is understanding the problem. At this stage, giving heuristic aims to direct students to understanding concepts so that they can communicate phenomena that exist in various forms and in the language of mathematics, and students can have good creativity. The second stage is planning a solution. At this stage heuristic is aimed at directing students to be able to make completion plans by giving several heuristics so that students can be creative to communicate the elements and traits that exist so that a settlement plan or mathematical model can be used to solve existing problems.

The third stage is carrying out the completion plan. Heuristics are given to direct students to find conclusions, traits or solve existing problems, so that students have the ability to find and solve existing problems. The fourth stage is checking again. The provision of heuristics aims to direct students to check the correctness of the steps taken and the results obtained. The implementation of the heuristic strategy will have an impact on students’ reasoning abilities.

HIGH ORDER THINKING IN MATHEMATICS

Measuring mathematical abilities used several items in accordance with the targeted test material. Indicator of mathematical ability that refers to HOT, namely the ability to understand concepts, mathematical communication (Madu, 2017), creativity, problem solving (Setiawan, 2014; Wardhani, 2015), and reasoning (Brookhart, 2010). Concept understanding can be interpreted as a basic understanding ability that can be used to classify an object. Understanding concepts is the ability of students to restate what has been learned (Duffin & Simpson, 2000). Operational indicators to measure the ability to understand concepts, namely (1) explain the concept in various ways, (2) classify according to its properties, (3) explain the requirements needed for an understanding, (4) show an example form of a concept, (5) show form is not an example of a concept, (6) use concepts for problem solving, (7) use concepts for problem solving.

Communication is an important part in every learning activity. Mathematics is a symbolic language that can be used in science. Mathematics is a language that can be used in communication (Armianti, 2009). Studying mathematics means having mathematical communication skills (Dan, 2013). The benefits of mathematical communication in learning mathematics are as a capital for mathematical completion (Greenes & Schulman, 1996), and as an important condition for communicating various ideas into the language of mathematics (Baroody, 1993). Operational indicators for measuring mathematical communication skills, namely (1) reflecting things into the language of mathematics, (2) explaining the typing through mathematical symbols (3) explaining mathematical problems or problems through the language of mathematics, (4) explains how to make a story based on a picture or mathematical model, (5) describes how to translate everyday problems into mathematical language.

Creativity is one’s ability to produce new things. Munandar (2012) states that creativity is the ability to create something new. Creativity is a cognitive activity that produces a new way of looking at a problem (Solso, 1995). Creativity in mathematics is defined as the ability to see and choose a solution in mathematics (Sriraman, 2011). Some aspects of mathematical creativity, namely flexibility, fluency, novelty, sensitivity, originality, and elaboration (Evans, 1991; Silver, 1997). Operational indicators to measure the ability of mathematical creativity, namely (1) explain some examples of solving mathematical problems until all

students understand, (2) explain some understanding of an image, pattern, diagram, or mathematical problem, (3) explain in several ways to solve math problems, (4) explain in several ways to find alternative answers from a problem or mathematical problem, (5) develop an idea or idea to solve a mathematical problem.

Learning mathematics means learning a problem, namely a question in mathematics to be solved (Baroody, 1993; James, 1976; Tambunan, 2014), and a question becomes a matter problems if there are no certain rules can be used to solve them (Hudoyo, 2005). Operational indicators to measure problem solving abilities, namely (1) explain what is known and asked in story problems, (2) explain the adequacy of the elements known to answer the questions asked in the story, (3) explain how to make a mathematical model of a story problems or mathematical problems, (4) solving mathematical models systematically. Reasoning is a process of thinking in drawing conclusions based on inductive and deductive (Sumantri, 2009). Operational indicators for measuring mathematical reasoning ability, namely (1) stating definitions, propositions, theorems, problems or problems with their own language orally or in writing, (2) presenting statements, problems or mathematical problems through sketching pictures, patterns, tables or diagrams, (3) translating a daily problem into the language of mathematics, (4) directly proving a statement (formula, proposition or theorem) of mathematics, (5) checking the truth a mathematical problem solving, (6) drawing conclusions from a mathematical statement or solving a mathematical problem, (7) arranging the form, pattern or properties of mathematics to make general conclusions.

METHOD

This descriptive research uses a correlation design. The population of this study were all students of the second grade of state and private high schools, the 2018-2019 academic year represented by eight schools and districts in the province of North Sumatra, and from each school randomly sampled 257 students ($N = 257$).

Data collection techniques were carried out by giving questionnaires and tests to students. The questionnaire contains questions about students' responses to the implementation of heuristic strategy (X) with the syntax of understanding of the concept (X1), creativity (X2), mathematical communication (X3), problem solving (X4), and reasoning (X5). Test consists of several items that include the ability to HOT (Y) with indicators of understanding of the concept (Y1), creativity (Y2), mathematical communication (Y3), problem solving (Y4), and reasoning (Y5) in the linear program material. Data analysis used linear regression through covariance analysis (Mann, 2011).

RESULT

Based on the results of linear regression analysis through analysis of variance (ANOVA) with SPSS version 19, the following results were obtained. The influence of heuristic strategy on students' mathematical abilities with high order thinking is generally described in the results of linear regression analysis in the following table.

Table 1. Model Summary of Predictors X and Dependent Variable Y

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.869	.755	.754	7.28981

a. Predictors: (Constant), X

Table 2. ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.	
1	Regression	41703.066	1	41703.066	784.757	.001
	Residual	13551.051	255	53.141		
	Total	55254.117	256			

a. Predictors: (Constant), X

b. Dependent Variable: Y

The analysis results in **Table 1** and **Table 2** show that the predictor x greatly influences the independent variable Y. That means that the heuristic strategy is very influential on the mathematical ability of students with HOT whose influence is 75.5%. The results of the analysis simultaneously heuristic strategy on mathematical abilities are described as the following table.

Table 3. Model Summary

Table 3. Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.895	.801	.797	6.61728

a. Predictors: (Constant), X1, X2, X3, X4, X5

Table 4. ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
1					
Regression	44263.222	5	8852.644	202.169	.001
Residual	10990.895	251	43.788		
Total	55254.117	256			

a. Predictors: (Constant), X1, X2, X3, X4, X5

b. Dependent Variable:Y

Based on **Table 3** and **Table 4** it is shown that simultaneously heuristic strategies affect students' mathematical abilities, and the effect is 80.1%

Furthermore, the results of partial linear regression analysis heuristic strategy for mathematical abilities are described as in **Table 5**.

Table 5. Summary of partial regression analysis heuristic strategy for mathematical abilities

Var.	Y1		Y2		Y3		Y4		Y5	
	R ²	F	R ²	F	R ²	F	R ²	F	R ²	F
X1	0.614	408.799**								
X2			0.480	235.174**						
X3					0.625	425.089**				
X4							0.513	269.124**		
X5									0.622	419.722**

Based on the summary of partial regression analysis in **Table 5** shows that significantly heuristic strategy affect on each indicator of mathematical ability with high order thinking. The influence of heuristic strategy on concept understanding, creativity, mathematical communication, problem solving, and reasoning were 61.8%, 48.0%, 62.5%, 51.3%, and 62.2% respectively.

DISCUSSION

The results of this study indicate that heuristic strategy greatly influence the mathematical ability of students in thinking high orders. This is consistent with the results of research that shows that learning strategies can improve students' abilities (Fauziah, 2010), and the heuristic approach is better than conventional towards student achievement (Abonyi, 2014). Partially heuristic strategy affect the mathematical ability of students in high order thinking (HOT). The effect of heuristic strategy on concept comprehension ability is 61.8%. This is consistent with the results of the study that learning using learning strategies can affect the ability to understand concepts (Alifiani, 2017; Hadi & Kasum, 2015; Sari, 2017; Sumaryati & Hasanah, 2015).

The effect of heuristic strategy on creativity ability is 48.0%. This is consistent with the results of the study that learning strategies can improve mathematical creative thinking skills (Nanang, 2016; Sormin, 2016; Rahmazatullaili, 2017; Rochani, 2016). The effect of heuristic strategy on mathematical communication ability is 62.5%. This consistent with the result of the study that learning with a strategy can improve students' mathematical communication (Anggreni & Sumarno, 2013; Fatmasuci, 2017; Habsah, 2017; Hodiyanto, 2017; Kleden, 2017).

The effect of heuristic strategy on problem solving ability is 51.3%. The results are in accordance with Chavez's (2007) statement that heuristics are effectively used in problem solving. Heuristics provide positive results on problem solving abilities (Hoona, 2013; Novotna, 2014). The influence of heuristic strategy on reasoning ability is 62.2%. This consistent with the result of the study that learning with strategies is better than a conventional approach to reasoning ability (Ario, 2016; Satriawan, 2017; Sumartini, 2015; Wibowo, 2017; Yumiati & Noviyanti, 2017).

CONCLUSION

Heuristic strategy is a learning approach by giving heuristics to problem solving steps. The implementation of mathematics learning, the use of heuristic strategies can be used to direct students to conceptual understanding, creativity, mathematical communication, problem solving and reasoning, so that students have high order thinking skills (HOTS). Based on the results of this study it can be stated that heuristic strategies have a strong influence on students' mathematical abilities in high order thinking (HOT).

Partially heuristic strategy influences students' abilities in each HOT indicator, namely the ability of concept understanding, creativity, mathematical communication, problem solving and reasoning ability.

Disclosure statement

No potential conflict of interest was reported by the authors.

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