

Performance of mathematics teachers to build students' high order thinking skills (HOTS)

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ABSTRACT

The purpose of this study is to determine the mathematics teacher performance category in building high order thinking skills (HOTS) of students. The study was conducted on 560 students taken randomly from ten junior high schools and eight high schools from eight districts in North Sumatra Province. Data collection techniques and instruments are carried out by giving questionnaires to students which contain a number of questions about students' assessment of the mathematics teacher's performance in constructing the HOTS indicator. Based on descriptive analysis, it was found that the performance of mathematics teachers built HOTS indicators, namely (1) understanding of concepts, (2) mathematical communication, (3) creativity, (4) problem solving, and (5) reasoning is enough category. The results of analysis of variance show that teacher performance builds (1) understanding of concepts, (2) mathematical communication, (3) creativity, (4) problem solving, and (5) reasoning significantly influences students' abilities.

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1. INTRODUCTION

High order thinking skills (HOTS) for students become an important issue in Indonesia at this time, because the average national mathematics test scores are decreased due to problems referring to HOTS in accordance with the PISA standard [1]. The PISA standard problem requires reasoning, analysis, evaluation, creation and problem solving abilities [2, 3]. HOTS include the ability of logic and reasoning, analysis, evaluation, and creation, problem solving, and judgment [4]. The importance of HOTS in learning mathematics so students can find new challenges [5], mastering mathematics well [6], as a basis for students' skills in problem solving, reasoning, and mathematical communication [7]. Some research results show that there was a significant relationship between HOTS and student learning outcomes [8-10]. Many factors influence HOTS students in mathematics, both internal and external factors. Judging from external factors, such as the learning process is not good [11, 12], the interaction of teaching methods is not good [13], teachers are not good at choosing learning strategies [14], questions are not in accordance with students' abilities [15, 16], the teacher does not carry out his role as a motivator [17]. Therefore, the success of students having HOTS towards mathematics is influenced by the ability of teachers through learning. Some research results show that the use of learning strategies or models can increase HOTS students [18-23].

Based on Bloom's taxonomy [24], the level of thinking can be divided into two, namely the Lower order thinking skills (LOTS) and HOTS. Aspects of knowledge, understanding, and application require LOTS, while aspects of analysis, synthesis, evaluation, and creation require HOTS [25], the ability of students in LOTS includes remembering and understanding. Building LOTS means building understanding

of mathematical concepts and communication. HOTS capabilities include application, analysis, synthesis, and evaluation. That means, building HOTS is building reasoning, creativity and problem solving. Therefore, the success of students having HOTS in mathematics is influenced by factors such as the ability of teachers to build students' abilities in LOTS and HOTS through learning concept understanding, mathematical communication, creativity, problem solving and reasoning.

The concept can be interpreted as a basic understanding that can be used to classify an object. Understanding concepts is an important part of mathematics learning, because understanding concepts means understanding the characteristics of the material. Understanding mathematical concepts well will make it easier for students to learn mathematics. Concept understanding is the ability of students to re-express what has been learned [26]. Building understanding of concepts can be done through good learning. The results of the study show that learning using learning models can improve concept comprehension skills [27-30]. Some operational syntax that can be done by the teacher to build understanding of concepts are (1) explaining definitions, general forms, theorems in various ways, (2) classifying elements of the discussion material based on its properties, (3) explaining the required conditions of a understanding, (4) showing an example form of a concept, (5) showing form not an example of a concept, (6) using concepts for problem solving, (7) using concepts for problem solving.

Communication is an important part of every learning activity, and in order to be able to communicate well, language is needed. Mathematics is the language of symbols that describes real problems as the language of symbols, and can be used as a language of communication in science. Mathematics is one language that can also be used in communication [31]. Studying mathematics means having mathematical communication skills, namely the ability to understand and express facts, thoughts and mathematical ideas [32]. The benefits of mathematical communication in the learning of mathematics are as a capital of success for students towards approaches and solutions in mathematical exploration [33], and as an important requirement, to communicate kinds of clear and concise ideas into the language of mathematics [34].

There are three indicators of mathematical communication skills in mathematics learning, namely (1) the ability to express mathematical ideas through oral, written, demonstration, and visual drawing, (2) the ability to understand, interpret, and evaluate mathematical ideas, both verbally as well as in other visual forms, (3) the ability to use terms, mathematical notations and their structures to present ideas, describe relationship relationships and situation models [35]. Mathematical communication can be built through good learning. The results of the study show that learning by using learning strategies or models can improve students' mathematical communication [36-40]. Some operational syntax that can be done by the teacher to build mathematical communication, namely (1) explain how to change or reflect real objects, images, patterns, or diagrams into a language or mathematical symbol, (2) explain the meaning of mathematics learning material through pictures, patterns, diagrams, or mathematical symbols (3) explain mathematical problems or problems by sketching pictures, patterns, diagrams, or mathematical models, (4) explaining how to make a story based on pictures, diagrams, patterns, or mathematical models, (5) explain how to translate everyday problems into mathematical language.

Creativity is one's ability to produce new things. Munandar [41] 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 [42]. Creative thinking is a mental activity used to construct a new idea [43], and mathematical creative thinking is a combination of logical thinking and divergence [44]. Creativity in mathematics is defined as the ability to see and choose a solution in mathematics [45]. Some aspects of mathematical creativity namely flexibility, fluency, novelty, sensitivity, originality, and elaboration [46-48]. Mathematical creativity can be built through learning. The results of the study show that learning strategies or models can improve mathematical creative thinking skills [49-52]. Some operational syntax that can be done by the teacher to build 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 with 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 to solve a mathematical problem.

Learning mathematics means learning and completing concrete and abstract problems that are useful to train students to overcome existing problems, both in terms of science and in everyday life. Problems in mathematics are a question in mathematics to be solved [53, 34, 54]. While questions in mathematical questions are made into problems if there are no certain rules that can immediately be used to solve them [55]. Polya [56] states four stages of problem solving, namely (1) understanding the problem, (2) planning the solution, (3) completing the resolution plan, and (4) look back. Problem solving abilities can be built through learning, research results show that learning strategies or models can improve problem solving abilities [57]. Some operational syntax carried out by the teacher to build problem-solving skills, namely (1) explain what is known and asked in the problem, (2) explain the adequacy of the elements known, to answer

the questions asked, (3) explain how to make a model mathematics of a matter of mathematical problems, (4) completing a mathematical model systematically.

Reasoning is the right thinking process to get a conclusion. Reasoning is a process of thinking in determining a conclusion based on inductive and deductive [58]. Suparno [59] defines reasoning as a process of systematic and logical thinking to obtain a conclusion of knowledge or belief. The ability of students' mathematical reasoning can be built through various learning strategies or models. The results show that learning using strategies or learning models is better than conventional learning [60-64]. Some operational syntax that can be done by the teacher to build mathematical reasoning, namely (1) stating mathematical 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 correctness of a mathematical problem, (6) draw conclusions from a mathematical statement or the completion of a mathematical problem, (7) arrange the form, pattern or properties of mathematics to make general conclusions.

If the operational syntax outlined above is carried out by the teacher well then HOTS students will be better, as a result the learning achievement of mathematics will be better too. The question is: "How does the performance of mathematics teachers build student HOTS? and does HOTS affect students' mathematical abilities?". This study aims to determine the mathematics teacher performance category in building HOTS students, and to find out whether or not HOTS influences students' mathematical abilities. The results obtained can be useful as a basis for overcoming the problems of the national mathematics exam that refers to HOTS.

2. RESEARCH METHOD

This type of research is ex post facto, that is a research that reveals the incident has passed. This research was conducted in secondary schools in the odd semester of 2018/2019 school year. The study population was all students in ten junior high schools and eight high schools from eight districts in North Sumatra Province. A sample of 560 students was taken randomly from one class at each school that was selected. Data collection techniques and instruments are carried out by providing questionnaires and math problems (Y) referring to HOT students. Questionnaire contains a number of questions about students' assessment of mathematics teacher performance in building indicators of high order thinking skills (HOTS), namely understanding concepts (X1), mathematical communication (X2), creativity (X3), problem solving (X4), and reasoning (X5). Data analysis techniques used descriptive analysis, and analysis of variance (ANOVA) [65]. ANOVA was used to determine the effect of teacher performance on students' abilities, and descriptive analysis was used to describe mathematics teacher performance categories. The description technique is used and modified the intervals and criteria made by Sudijono [66] as in Table 1.

Table 1. Data Interval and Category

Interval	Category
$X > \bar{X}_i + 1.8 Sd_i$	Very good
$\bar{X}_i + 0.6 Sd_i < X \leq \bar{X}_i + 1.8 Sd_i$	Good
$\bar{X}_i - 0.6 Sd_i < X \leq \bar{X}_i + 0.6 Sd_i$	Enough
$\bar{X}_i - 1.8 Sd_i < X \leq \bar{X}_i - 0.6 Sd_i$	Less
$X \leq \bar{X}_i - 1.8 Sd_i$	Not good

3. RESULTS AND ANALYSIS

Based on the results of descriptive analysis using SPSS version 19, the mathematics teacher's performance builds HOTS students as described in Table 2.

Table 2. Descriptive Statistics of The Performance of Mathematics Teachers to Build HOTS

Statistics	Statistical Value					
	X1	X2	X3	X4	X5	Y
N	560	560	560	560	560	560
Mean	21.01	14.83	14.81	11.84	18.93	67.78
Std Deviasi	2.54	2.48	3.64	2.38	2.58	17.47
Maksimum	26.00	25.00	25.00	25.00	25.00	97.00
Minimum	11.00	8.00	6.00	5.00	7.00	5.00

Based on Table 2, and guided Table 1, a description of the frequency and percentage of the performance categories of mathematics teachers is presented as follows in Table 3.

Table 3. Description of Frequency, Percentage and Performance Categories of Mathematics Teachers to Build HOTS Indicator

No	X1		X2		X3		X4		X5		Category
	F	%	F	%	F	%	F	%	F	%	
1	2	0.4	33	5.9	88	15.7	19	3.4	8	1.4	Very good
2	95	17.0	62	11.1	59	10.5	57	10.2	54	9.6	Good
3	333	59.5	310	55.4	199	35.5	324	57.0	382	68.2	Enough
4	97	17.3	136	24.3	173	30.9	143	25.5	84	15.0	Less
5	33	5.9	19	2.2	41	7.3	17	3.0	32	5.7	Not good

Based on the frequency and the largest percentage in Table 3, the performance of the mathematics teacher building the HOTS indicator can be stated in Table 4.

Table 4. Performance Categories of Mathematics Teachers to Build HOTS

Var.	Indicators	F	%	Category
X1	Concept Understanding	333	59.5	Enough
X2	Mathematical communication	310	55.4	Enough
X3	Creativity	199	35.5	Enough
X4	Problem solving	324	57.0	Enough
X5	Reasoning	382	68.2	Enough

Based on Table 4, it can be stated that all indicators for HOTS are sufficient categories. So that it can be concluded that the performance of teachers building HOTS is a sufficient category. This category has an impact on students' ability to solve math problems with high order thinking (HOT). This is in accordance with the results of ANOVA shows that (1) the performance of teachers to build understanding of concepts significantly affect the ability of students, where the value of F count (F^*) = $5.771 > F_{(1,558)} = 3.856$, (2) the performance of teachers to build mathematical communication significantly affect student ability, where $F^* = 4.649 > F_{(1,558)} = 3.856$, (3) teacher performance build creativity significantly influences student ability, where $F^* = 7.280 > F_{(1,558)} = 3.856$, (4) teacher performance build indicator Problem solving significantly affects students' abilities, where $F^* = 9.079 > F_{(1,558)} = 3.856$, and (5) teacher's performance in building reasoning indicators significantly influences students' abilities, where $F^* = 13.561 > F_{(1,558)} = 3.856$. The influence is in accordance with the results of the study that there is a significant relationship between HOTS with student learning outcomes [8-10]. Therefore, so that students can solve math problems properly, the ability of the teacher to build high-order thinking skills must also be good.

4. CONCLUSION

Based on the results of this study it can be stated that the performance of mathematics teachers build indicators of concept understanding, mathematical communication, creativity, problem solving, and reasoning are sufficient categories. This will have an impact on students' ability to solve math problems with high order thinking (HOT). The results of ANOVA show that teacher performance builds (1) understanding of concepts significantly influences students' abilities, (2) teacher performance in building mathematical communication significantly influences students' abilities, (3) teacher performance builds creativity significantly influences students' abilities, (4) performance teachers build problem-solving indicators significantly affect students' abilities, and (5) teacher's performance in building reasoning indicators significantly influences students' abilities. Therefore, so that the results of the mathematics national examination are well achieved, it is necessary to improve the ability of teachers to develop HOTS in mathematics education.

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