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Thinking Profile of Mathematics Teachers in Solving HOTS Problems

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Abstract

HOTS questions are given by teachers in learning with the hope that students will be able to think at a higher level. The aim of this research is to obtain a profile of mathematics teachers' thinking in solving HOTS problems. The research method used is a qualitative approach. The research subjects were SMA/SMK/MA teachers who worked and lived in Madiun, Magetan, Ngawi, and Ponorogo. Data collection uses tests and in-depth interviews. Source and time triangulation is used to obtain valid data. Categorization, reduction, and coding are used for data analysis so that conclusions can be drawn. Mathematics teachers solve HOTS problems by understanding, planning, implementing, and checking again. When understanding, mathematics teachers take the information contained in the problem given and bring it into mathematical form. At the understanding stage, teachers can identify the suitability of problems with their knowledge, such as linear programming problems. This is done by considering possible answers according to the information available on the problem. When implementing, according to the choices decided, the teacher carries out the plan. Implementation of the plan is the teacher's answer to solving the given HOTS problem. When rechecking, in general, perhaps because of the hassle, some mathematics teachers do not recheck answers. Only after there has been a discussion do most math teachers check their answers again. At this stage, it is possible for the teacher to find doubts and decide on confidence in the answer.

Keywords: Thinking, teachers, solving, HOTS, Problems.

Introduction

In learning, the teacher often gives questions to students about HOTS (Higher Order Thinking Skill). HOTS questions are given in learning with the hope that students are able to think at a higher level. HOTS-type questions usually provide unusual word choices and require advanced vocabulary and/or appropriate contextual understanding of the meaning of a word depending on its use in a sentence.

The teacher has a goal of giving HOTS questions. HOTS questions are expected to be able to encourage high-level reasoning so that they are not fixated on only one pattern of answers resulting from the memorization process, without knowing the scientific concept. HOTS questions can provide learning related to the demands of 21st-century skills, namely critical thinking, creativity, collaboration, and communication.

Providing HOTS questions can have a positive impact on students. solving HOT problems and training critical thinking, reasoning, and increasing creativity. Critical thinking is thinking by questioning, and challenging perceived knowledge and wisdom (Judge, Brenda; McCreery, Elaine; Jones, Patrick. 2009). Reasoning is thinking to reach a conclusion opinion or new decision from one or more known statements, decisions, or opinions (Dewantara, Agustinus W. 2018). Creativity is the ability to create something new by connecting several existing things.

This type of HOTS question started to boom in 2019. The strategy for developing HOTS questions in the 2013 curriculum needs to use certain strategies (Fanani, M. Z. 2018). The module for preparing HOTS questions needs to be developed (Widana, I. W. 2017). The development of HOTS questions should be related to local culture such as the rural context (Kristanto, P. D., & Setiawan, P. G. F. 2020). HOTS Question Preparation Training is needed for teachers (Manurung, I. D., Hasibuan, S. H., & Yusriati, Y. 2021). The development of HOTS questions was trained using Quizizz for Rural Elementary School Teachers (Rulyansah, A. 2022). A guide to writing HOTS questions already exists (Kemendikbud, P. P. P., & Abduh, M. 2019).

In general, teachers or lecturers group students based on their abilities. Due to its characteristics, most HOTS questions can only be solved by students with high-level thinking abilities. Higher-order thinking skills are needed in solving HOTS questions in mathematics (Saraswati, P. M. S., & Agustika, G. N. S. 2020). The ability to influence students in solving HOTS questions in the Department of Physics Education (Yusuf, I., & Widyaningsih, S. W. 2018). Some students experienced difficulty in solving HOTS questions. Analysis of student errors in solving hot questions can be based on mathematical reasoning abilities (Amalia, D., & Hadi, W. 2020). To be more specific, the analysis of students' errors in solving HOTS questions can be focused on material on curved side shapes (Anugrah, A., & Pujiastuti, H. 2020). In addition, an analysis of student errors in solving HOTS-type math problems can be based on theories such as Newman's Theory (Mahmudah, W. 2018).

Students' difficulties in working on HOTS type questions can occur not only because of student factors, but can also occur because of the question factors. Therefore, an analysis of the questions was carried out. Analysis of Higher Order Thinking Skill (HOTS) type mathematics questions in the 2013 curriculum was carried out to support students' literacy skills (Suryapuspitarini, B. K., Wardono, W., & Kartono, K. 2018). Analysis of higher order thinking skill (HOTS) type questions in National Examination questions also needs to be carried out (Lailly, N. R., & Wisudawati, A. W. 2015). Thus, developing questions to measure students' higher order thinking skills (hots) can produce optimal results (Suhady, W., Roza, Y., & Maimunah, M. 2020). Understanding the concept of HOTS assessment can influence the ability of SMA/SMK Mathematics teachers compiling HOTS questions (Widana, I. W. 2020).

Based on existing studies, the thinking profile of mathematics teachers in solving HOTS problems has not been studied. Teacher thinking profiles are important to research because students tend to imitate teachers. Students tend to imitate the teacher's way of thinking. Even in learning, teachers tend to follow their own way of thinking to explain to their students. By knowing the thinking profile of mathematics teachers in solving HOTS problems, students can imitate the teacher's way of thinking in solving HOTS problems. Apart from that, through the teacher's thinking profile in solving HOTS problems, it is possible to find new learning models so that students are able to solve HOTS-type problems.

Research Method

To obtain a profile of mathematics teachers' thinking in solving HOTS problems, qualitative research methods were used. The research was conducted in August 2023. The research location was Madiun City. The research flow is as follows.

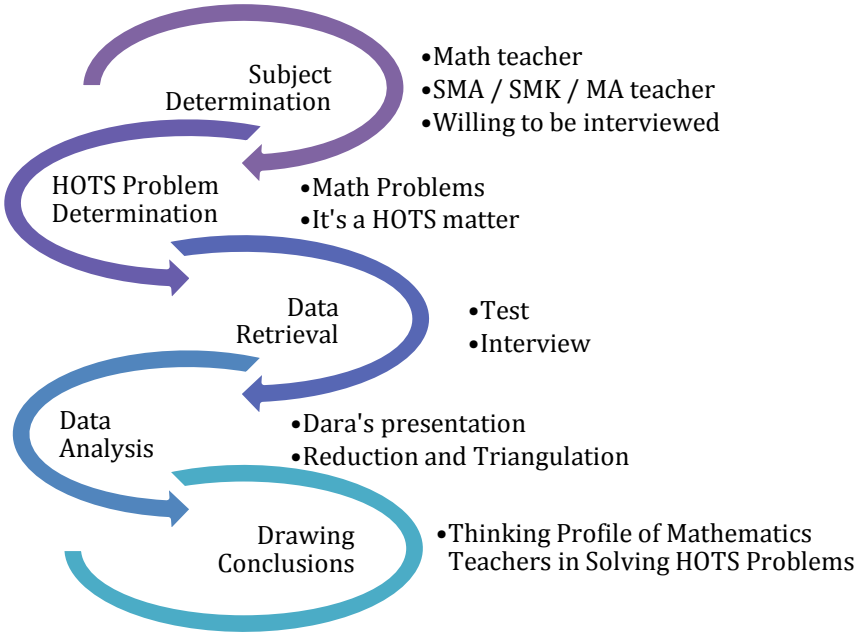

Figure 1. The Research Methods

The first stage carried out for this research was determining the subject. In accordance with the research objectives, the research subjects met the criteria as mathematics teachers. More specifically, SMA/SMK/MA teachers or equivalent are selected because the problems to be given are of the HOTS type. The selection of SMA/SMK/MA teachers is also based on considerations to ensure data collection. The target vocational/high school/MA teachers are vocational/high school/MA teachers domiciled in Madiun, Ngawi, Magetan, and Ponorogo. To ensure natural, broad, and in-depth data, subjects must be willing to be interviewed.

The second step is to determine the problem. In accordance with the research objectives, the problems raised must meet the criteria for math questions and be of the HOTS type. To ensure math problems, the questions are taken from math books. To suit the subject, the math

books used were high school/vocational high school math books. To ensure HOTS type questions, math questions that have been coded or marked as HOTS questions are selected. This was done due to time constraints.

After the HOTS subjects and questions are selected, the third stage is data collection. By using the selected HOTS questions, the subject is given a test to complete. In this research, data collection was carried out online using WA. This is done to save time and so as not to interfere with the subject's daily activities. Based on the test answers, confirmation is carried out by interview. This is done to obtain natural data. Apart from confirmation, in-depth interviews were conducted to obtain broad and in-depth data.

The fourth stage is data analysis. The data analyzed is valid data. Therefore, based on the data obtained, categorization, coding, and data reduction were carried out. Categorization was carried out to get the stages of mathematics teachers in solving HOTS problems. Coding is done to make it easier for researchers to trace the data. Data reduction is carried out on data that is irrelevant to the research objectives. If irregularities or lack of data are found, data is collected to complete the results of data analysis.

The final stage is drawing conclusions. Conclusions are drawn from the results of data analysis. In accordance with the objectives of this research, the conclusions at least contain the stages of thinking of mathematics teachers in solving HOTS problems. The stages of thinking of mathematics teachers in solving HOTS problems are reflected in the POLYA problem-solving theory. Other findings are still written down to get something new.

Result/Findings and Discussion

The research subjects were SMA/SMK/MA teachers who domicile and work in Madiun, Magetan, Ponorogo, and Ngawi. The number of target subjects is 18 teachers. After being given a test and to get the depth of the data, 1 high school mathematics teacher and 1 MA mathematics teacher were selected who were willing to be interviewed to provide information. Both informants are male. Even so, several questions needed to add information were still given to all subjects.

The problems taken are from the Mathematics book for SMA/MA class XI semester 1 (Interactive Book). The selected HOTS questions are as follows.

> Mr. Yudi has 96 hectares of land. He plans to use the land for goat and cow farming. Each animal will have its own cage. A goat's enclosure requires an area of 1 m^2, while a cow requires an area of 4 m^2. Mr. Yudi can only afford not more than 45 livestock. After some time, Mr. Yudi will sell all of his livestock. If Mr. Yudi wants the profit from selling cows to be twice the profit from selling goats, how many cows should Mr. Yudi raise so that he can get the maximum profit?
>
> a. 12 tails
> b. 17 tails
> c. 24 tails
> d. 28 tails
> e. 45 tails
>
> (Ngapiningsih, Suparno, Noviana Endah Santoso. 2018).

After reading the HOTS questions given, the subject understood. Some subjects read repeatedly to understand. The subject understands from the first sentence to the second sentence and so on. Because the subject's background is a mathematics teacher, when understanding the problem, it is brought to a mathematical form. The mathematical form of the problem is as follows.

Table 1. Teacher Understanding

Information from the Question	Mathematical Form
Mr. Yudi has 96 hectares of land.	1 hectare = 10000 m^2 96 hectares = 960000 m^2
He plans to use the land for goat and cow farming.	k = goat (kambing) s = cow (sapi)
Each animal will have its own cage. A goat's enclosure requires an area of 1 m^2, while a cow requires an area of 4 m^2.	$k + 4s \leq 960000$
Mr. Yudi can only afford not more than 45 livestock.	$k + s \leq 45$
After some time, Mr. Yudi will sell all of his livestock. If Mr. Yudi wants the profit from selling cows to be twice the profit from selling goats, how many cows should Mr. Yudi raise so that he can get the maximum profit?	$y = s + 2k$
How many cows should Mr. Yudi raise so that he can get the maximum profit?	s?

After understanding the problem given, the subject plans a solution. Some teachers plan solutions using linear programming. However, some teachers plan solutions using free thinking or reasoning. The teacher plans a solution using a linear program because after understanding it, it has occurred that the questions given are related to a linear program. For this reason, the teacher will rewrite the mathematical model resulting from his understanding, namely optimizing it. Up to this stage, you have imagined that problems can be solved using graphs, elementary line operations, or other methods. This stage ends with the teacher's activity of choosing or deciding to solve the problem using graphics. Direct graphics were chosen because they were considered the easiest compared to other methods.

Even though it has been reported that the questions are related to linear programming, some teachers plan the solution using free reasoning. The teacher chose to use this method because the questions were multiple choice type. Teachers don't need to use complicated charts by choosing the best from the available options. Teachers use this because they know the weaknesses of the multiple choice question type. By paying attention to the existing options and taking into account the existing obstacles, the best answer will be known. This stage ends with the teacher's activity of choosing or deciding to solve the problem using reasoning or free thinking.

After planning, the subject carries out the plan. Some teachers choose to solve problems using graphics. For this reason, the teacher rewrites the mathematical model that has been imagined when understanding. The teacher writes the system of equations to optimize or maximize $y = s + 2k$ with the constraints $k + 4s \leq 960000$ and $k + s \leq 45$ where $k, s \geq 0$. After carrying out operations on the graph, the teacher gives an answer with $s = 45$. An illustration of the teacher's solution using the graph is as follows.

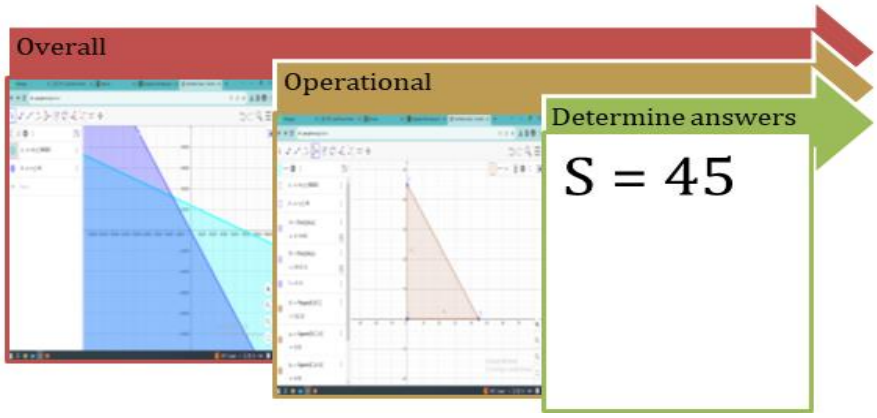

Figure 2. Teacher's Solution Using Graphs

Thinking using images is often known as visual thinking. Thinking using images can help in understanding (Darmadi, D. 2015). Thinking using images makes it easier to solve problems (Darmadi, D., & Handoyo, B. 2016). However, quite a few people experience difficulties when using images or graphics to understand or solve problems (Darmadi, D. 2017).

Although it appears that the problem is related to linear programming, some teachers prefer to carry out the plan using free thinking or reasoning. This was done because the HOTS questions given were multiple choice and given in relaxed conditions without coercion to work on linear programming theories. From the available choices, the teacher can choose the best answer. In the election, of course teachers are not arbitrary but with certain considerations. From the information related to land, the subject considered it too broad so it did not affect the answers. In a linear program it is called not an important constraint or can be viewed as an excess constraint. From the information that "Mr. Yudi wants the profit from selling cattle to be twice the profit from selling goats" and "Mr. Yudi can only afford to buy no more than 45 head of livestock", the subject concludes that the probability is 17 cows is 28 goats.

After carrying out or giving an answer, the subject checks again. Most teachers do not double check the answers. The teacher just gives the answer like that (the teacher's answers vary). Some of the teacher's answers are not thorough. Most teachers get stuck or forget that 1 hectare = 10,000 m2. After being reminded of the traps in the HOTS questions, the teacher checked again. Some teachers retract answers and do not give answers back. One teacher gave back answers and was active in the discussion. Discussion is part of the interview to obtain depth of answers. Based on the in-depth interviews, it was discovered that initially the teacher did not re-examine but after being criticized, the teacher carried out the re-examining activity.

Some teachers give answers using graphs. After checking again, the teacher who solved the problem using a graph gave the answer $s = 45$ and $k = 0$ so that the profit is optimal.

However, after the discussion, the teacher's doubts arose because the final answer given was contrary to Mr. Yudi's wishes where the profit from selling cows was twice the profit from selling goats. The answers given provide optimal profit, but the profit from selling goats is 0, which means it does not fulfill the desire that the profit from selling cattle is twice the profit from selling goats. Even so, the teacher still gave the answer that the number of cows kept was 45 head.

Some teachers give answers using free reasoning. After being checked again, the teacher who solved the problem using free reasoning gave the answer s = 17 and k = 28 so that the profit is optimal and the profit from selling cows is twice the profit from selling goats. However, after the discussion, the teacher's doubts arose because the final answer did not provide optimal benefits, besides that $s \neq 2k$. Despite this, the teacher still believes that the number of cows that must be kept is 17 heads and the number of goats is 28 heads. This was taken after looking again at the alternative answers given.

Conclusion

Mathematics teachers solve HOTS problems by understanding, planning, implementing, and checking again. When understanding, mathematics teachers take the information contained in the problem given and bring it into mathematical form. At the understanding stage, teachers can identify the suitability of problems with their knowledge, such as linear programming problems. When planning, according to their knowledge, mathematics teachers can solve it using graphs or other things. However, there are mathematics teachers who try to solve with free-thinking or reasoning. This is done by considering possible answers according to the information available on the problem. When implementing, according to the choices decided, the teacher carries out the plan. Implementation of the plan is the teacher's answer to solving the given HOTS problem. When rechecking, in general, perhaps because of the hassle, some mathematics teachers do not recheck answers. Only after there has been a discussion do most math teachers check their answers again. At this stage, it is possible for the teacher to find doubts and decide on confidence in the answer.

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