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Exploring the Types of Problems Task by Mathematics Teacher to Develop Students' HOTS

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Abstract. Higher-order thinking is an essential skill that should be developed in middle school students. One popular method in which mathematics teachers develop students' higher-order thinking skills (HOTS) is by giving mathematics problem assignments. This study aims to uncover the type of mathematics problem assignments used by novice and experienced teachers in junior high schools to develop students' HOTS. This descriptive qualitative study describes the type of mathematics problem assignment by two novice and experienced mathematics teachers at SMPN 3 Malang. Data were collected through observation and interviews. The results showed that (1) novice teachers chose assignments in the form of mathematics problems taken from books without regard to the familiarity of the context with the students. Moreover, the mathematics problem chosen is a closed-ended problem both in ways and solutions which was presented in core activities as an individual task to foster some HOTS skills namely, analysis and evaluation, (2) the experienced teacher chooses assignments in the form of mathematics problems designed by the teacher and paid attention to the familiarity of the context with students in the form of open-ended problem in ways and solutions which was presented in core activities where students were asked to work in groups to foster students' abilities in analysis, evaluation and create. For further research, it is necessary to reveal how the experienced teacher's thought process is in designing learning to teach HOTS so that it can be used as a reference by other mathematics teachers.

INTRODUCTION

One of the abilities that must be possessed by students in this 5.0 society is the skill to think at a higher level. Higher-order thinking skills (HOTS) is an essential skill for middle school students. These skills are needed to face real-life problems as HOTS is encouraging students to expand their thinking ability to face new challenges [1].

There are several definitions of higher-order thinking skills by some experts. HOTS is the ability to critically, logically, reflectively, metacognitively, and creatively thinking [2][3]. It encourages students to form concept, thinks critically, creatively brainstorms ideas, preserve their intelligent to follow sets of rules, as well as involves reasoning and logical thinking in problem-solving [4]. Besides, HOTS foster the ability of analysis, synthesis, and evaluation developed by Bloom. Furthermore, the three highest levels were revised by Anderson and Krathwohl [5] that HOTS is not only the ability to understand or apply concepts in solving the problem but also a process of analyzing, evaluating, and creating something. HOTS achievements in Indonesia are measured using the revised Bloom's taxonomy of analysis, evaluation, and creation [6].

One popular method employed by mathematics teachers to develop students' higher-order thinking skills is to give assignments in the form of problems [2]. Students are accustomed to solving problems through learning

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mathematics. This is also following the latest revised 2013 curriculum design in Indonesia, which demands the provision of problems in learning. Problems given in mathematics learning are mathematics problems that cannot be solved directly using algorithms that have been taught [7]. A higher level of thinking skills is required to overcome this problem requires.

Mathematics problems are a form of mathematics tasks with high cognitive demands [8]. To solve problem-based mathematics problems, students are required to not only apply the procedure directly but also do an analysis. The analysis should be in the form of exploration and connections between problems with procedures or formulas that have been mastered by students before [9]. Mathematics problems can be arranged with several types based on the number and clarity of the solution flow.

The solution can be a singular and plural solution given termed close-ended and open-ended problems [10]. A close-ended problem is a problem that has a specific and predetermined solution. While the open-ended problem is a problem that has many solutions or several ways to find the right solution, meanwhile, according to the clarity of the solution flow, the problem can be divided into well-structured and ill-structured problems. A well-structured problem has clear steps to the solution, while an ill-structured problem does not have clear steps to the solution [11].

In addition to the types of problems, the presentation of problem-based tasks can be done by various methods. Problem assignments can be presented by the teacher verbally or with the help of the media. The teacher can ask students to solve problems through group discussions, individual assignments, and dialogue between teachers and students [12]. The choice for the form of task assignments and methods of implementation in the classroom is essential for the teacher to develop the students' thinking skills.

The earlier Research on mathematics assignments to students [12] has examined various types of math assignments used by three sixth grade teachers in an elementary school. The results of the study have examined and illustrated how class-based factors could shape student involvement with mathematics assignments to encourage students to use advance mathematics thinking and reasoning ability [8]. Another research focuses on mathematics tasks as an essential vehicle for building students' capacity to think and reason mathematically [13].

These studies indicate that no research focuses on exploring the task in the form of mathematics problems to develop students' HOTS. It is essential to fully understand the type of mathematics problem assignment used as well as how the task is conducted by the teacher to develop students' HOTS. From the results of observations at one State Junior High School in Malang, there were differences in the types and patterns of assignment of mathematics problems between novice and experienced teachers. It is interesting to do an exploration of the types of math problem assignments presented by novice and experienced teachers to develop HOTS to students.

METHOD

Research Subject

The participants were recommended by the head of the Mathematics subject teacher deliberations of Junior High School in Malang, mathematics teacher at SMPN 3 Malang. According to the head of the Mathematics subject teacher deliberations, the school was recommended based on the fact that the average achievement of students' mathematics learning outcomes was better compared to other junior high schools in Malang. The results of preliminary observations, from the six mathematics teachers in junior high school, the researchers were interested in two teachers because they more often gave various problem types to their students. These two teachers were from now on, referred to as initials N and E. N is a female teacher who graduated from undergraduate mathematics education with two years of teaching experience. Whereas E is a female teacher graduating from mathematics education with 18 years of teaching experience. So it can be said that N is a novice teacher, and E is an experienced teacher.

Data Collection and Analysis

Data have been collected through observations of the participants for about one month. The researcher observed both participants in investigating a dominant pattern in the type of assignment given to students. It is because every teacher has confidence in learning, including presenting problem assignments to the students [14]. The type of problem assignment was observed based on the type of mathematics problem presented and how the task is implemented to develop students' HOTS. Besides, researchers also conducted unstructured interviews. Interviews

were conducted to support observational data on the types of mathematics problem assignments presented by the subject.

TABLE 1. Type of Math Problems to Develop Students' HOTS

Types of Mathematics Problems		Application of Mathematics Problems	HOTS Achievements
Number of solutions [10]	Closed-ended problem	Tasks are given by: – Individual, – Groups, – Direct questioning between teacher and student [12]	– Analysis (C4): selecting, organizing material into the principal elements and determining how the relationship/relation of one element to another, – Evaluation (C5): makes judgments or decisions based on criteria or standards, – Create (C6): take all the essential elements to make something that has a function or reorganize existing elements into a new structure or pattern [5]
	Open-ended problem		
Clarity of solution flow [11]	Well-structured problem		
	Ill-structured problem		
Problem context [15]	Contextual for students		
	Not contextual for students		

Data analysis was performed by selecting an assignment of mathematics problems that reflected the subject's beliefs. Data from observations and interviews are presented and reduced. Meanwhile, to obtain credible data, triangulation was conducted from observations and interviews [16].

RESEARCH AND DISCUSSION

Novice Teacher

Participant N presented assignments in the form of problems to students in the core learning activities. The problem was chosen by participant N from the student book used in mathematics learning.

Translation:
A diver from the SAR Team hooked himself to a 25 m rope to search for the remains of the wreckage on the seabed. The sea has 20 meters of depth and is flat. What is the area that can be reached by divers?

FIGURE 1. Mathematics Problem Task by Subject N

The problem in Figure 1 was chosen by participant N because students had never been given this type of problem, so he thought the question was a problem for students. This is supported by quotes from interviews with participant N.

R: Are you sure that the assignment is a problem for students?
N: Yes, because my students chose questions in the books where students could not directly find the answers. The question that I chose was not a matter of routine and was related to daily life.
R: How are the characteristics of the problem that you gave when viewed in terms of a solution?
N: If the problem had a single solution that was finding the area of a triangle by first determining its base

The opinion of participant N is in line with Pehkonen [17] that a person is said to encounter a problem when facing a question that he cannot solve with the knowledge that is immediately available to him. The mathematics problem presented by participant N is a closed-ended problem with a single solution. Closed-ended problems are problems that have only one solution or one strategy [10]. The context of the problem given to students is not familiar to be encountered by students, but students can imagine it. It is because students at this junior high school live far from the sea. However, the problem can be said to be a contextual problem that refers to familiar and meaningful situations for students [18]. On the problem presented, students are asked to determine the area covered

by divers when looking for the remains of a wreck. The problem type presented by participant N is a problem with a clear solution path, so making it a well-structured problem [11] [19].

FIGURE 2. Students Solve Problems Individually

In presenting assignments, participant N asks students to work on the assignments individually, as shown in Fig. 2. According to participant N, by assigning mathematics problems individually, students will organize the known information, the intended questions, and choose strategies for problem-solving independently and not depend on other friends. This is supported by the following interview from the participant.

R: Why did you ask students to work individually?

N: In my opinion, by asking students to do it themselves, students are responsible independently in solving problems, looking for what was known and what was asked. Then students chose and implemented strategies that are appropriate for problem-solving.

R: Did you train high-level thinking with students?

N: Yes, because students analyze what was known, what was asked, and chose an appropriate strategy to solve the problem. In addition, I also asked students to check the truth of each student's answers.

From these activities, participant N accustomed to students to analyze one aspect of HOTS. After that, participant N asks students to check the results of their completion, after which students were asked to present their findings in the class while other students were asked to check their friends' answers. In this answer checking activity, participant N accustoms students to conduct an evaluation, which is one of the activities to develop students' HOTS. From the activity of applying the mathematics problem assignment, it appears that participant N develops students' HOTS, which includes analysis (C4) and evaluation (C5).

Experienced Teacher

Participant E presented the task of mathematics problems in core learning activities. The problem assignment presented was a matter created/developed by participant E.

Translation:
Students are invited to the aquarium in the lab. If this aquarium contains 3/5 of its water and filled with brick for decoration with a volume of 65 dm3. What happens to the water in the aquarium? (Spilled / not spilled)
Explain your reason!

FIGURE 3. Mathematics Problem Task by Subject E

Participant E believes that the question he made in Fig. 3. was a problem for his students because students cannot directly solve it using their prior knowledge [17]. This is also evident in the interview with participant E.

R: Are you sure that the assignment was a problem for students?

E: Sure. Because I made it my self by modifying from existing problems, both those in books and those I have made before, the problem that I created was developed by not showing the size of the aquarium directly and asking for opinions and reasons from students.

R: How are the characteristics of the problem that you created when viewed in terms of the solution?

E: The solution to the problem I gave is open to students. The answers vary depending on the size of the aquarium specified by the student. Opinions and reasons are also open, depending on student answers.

Mathematics problems were created by the teacher in the context of aquariums in the school lab. The choice of context on this problem is a context that is close and familiar to students. The mathematics problem presented was an open-ended problem with the incomplete structure in the matter of the volume of geometric space. In the problem presented, students were asked to determine how the water conditions in the aquarium. The size of the aquarium was unknown and depended on the aquarium in the lab, so the flow of the solution of the problem presented by the teacher was said to be unclear. Besides, opinions and reasons also depend on what was conveyed by students. Thus this problem was ill-structured [11][19].

FIGURE 4. Students Solve Problems in Groups

In presenting problem assignments, participant E asked students to work on problem assignments in groups of 3-4 students. Through assigning mathematics problems in groups, students would organize what was known, what was asked, and chose strategies for solving problems through discussion with friends in the group. From this activity, participant E familiarized students with analyzing one of HOTS [5]. This is shown in the following interview excerpt.

R: Why did you ask students to work in groups?

N: Through activities in groups, students could discuss, understood the problems, and implement problem-solving strategies. Students with high abilities can help students who are lacking.

R: Did you train high-level thinking with students?

N: Yes, students as a group analyzed the problem given by determining the size of the aquarium themselves and choosing strategies to solve the problem. Students checked the answers in the group and compared them with other groups.

The completion of the problem assignment presented by participant E has several solutions that depend on students' assumptions. This trained students to create creations in determining the size of the aquarium and use a method designed by students to determine the condition of the water in the aquarium. After that, participant E asks students to check the results of their completion with classmates. Participant E asked several groups to present their answers in front of the class and asked other groups to check the answers of their friends. In this answer checking activity, participant E accustoms students to conduct an evaluation, which is one of the activities to develop HOTS. Students were trained to make judgments or decisions [5] on finding the right solution to the problem in terms of accuracy, the correct way, and the final solution of the problem. From the activities of applying the mathematics problem task, it appears that participant E has trained HOTS to students, which include analysis (C4), evaluation (C5), and creation (C6).

The analysis results show that there are differences in the types of mathematics problems assigned by participants N and E presented in Fig. 5.

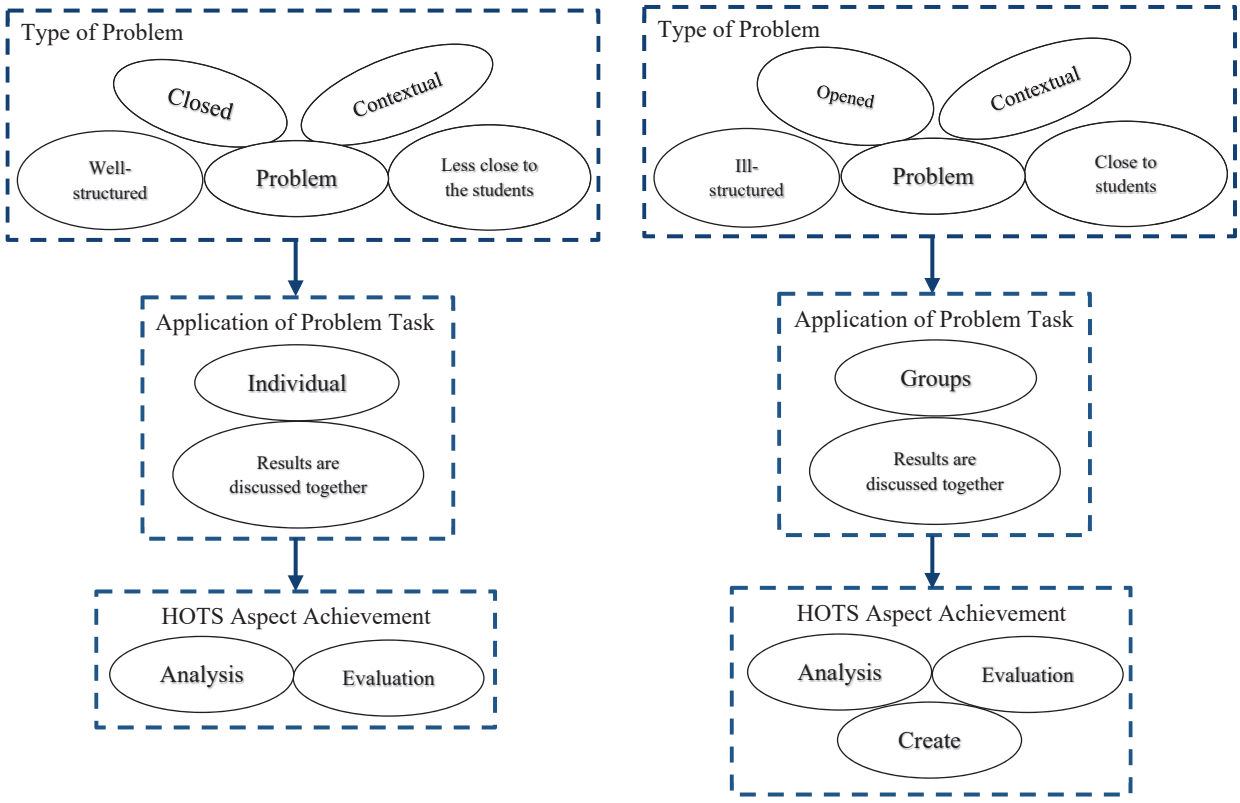

FIGURE 5. Type of Mathematics Problem Task by Participant N and E

Figure 5. shows the different types of problems presented by participant N, and E. Participant N provides a closed-ended, structured, and contextual problem that was less familiar to students. In contrast, subject E provides open-ended, incomplete, and contextual problems that were close and familiar to students. Participants N and E make decisions in choosing problem tasks for students [20]. Participant N asked students to work on an individual basis while participant E asks students to work on the problem in groups. This implies some careful consideration in choosing assignments, the problems, experiences, and reference frameworks to ensure that it makes sense for students and potentially to involve students in a mathematics activity goal [18]. To achieve HOTS, participant N practiced analysis and evaluation while participant E practiced analysis, evaluation, and creation. The type of problem-based assignments and HOTS achievements showed that teaching experience is very influential on the quality of the problem-based assignment given to students. This is in line with Lachner, Jarodzka, and Nückles [21], those novice teachers have a superficial analysis of the choice of assignments which resulted in non-optimal student learning outcomes [22].

CONCLUSION

The results showed that (1) novice teachers chose assignments in the form of mathematics problems taken from books without regard to the closeness of the problem's context with students, the chosen mathematics problem was a closed-ended problem both in ways and solutions which were presented in core activities to be solved individually by students, (2) experienced teachers chose assignments in the form of mathematics problems designed by the teacher and paid attention to the closeness of the problem context with students, the chosen mathematics problem was open-ended in away. It closed to a solution which was presented in core activities to be solved in groups. HOTS developed by students by novice teachers is when students analyze problem assignments individually. From the results obtained individually, the students then evaluated the answers themselves and with their friends. Whereas HOTS developed by an experienced teacher is developed when students are doing problem analysis by discussing in groups followed by evaluation activities on the answers of other groups. Experienced teachers also trained students to create several ways to obtain solutions to a given problem. Thus, based on Bloom's revised taxonomy, HOTS,

which was trained by novice teachers, includes analysis and evaluation, while those trained by experienced teachers are analysis, evaluation, and create. For further research, it is necessary to reveal how the experienced teacher's thought process is in designing learning to teach HOTS to students so that it can be used as a reference by other mathematics teachers.

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