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Mathematical Critical Thinking Ability in Solving Open-Ended Questions Viewed from Students' Curiosity

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Abstract

The purpose of this study was to determine the effect of the level of curiosity on students' mathematical critical thinking abilities in solving open-ended problems and describe the students' mathematical critical thinking skills in solving open-ended problems in terms of students' level of curiosity. This study was a mixed-methods study with sequential explanatory design. The results showed that (1) there was a significant influence between students 'curiosity on students' mathematical critical thinking abilities in solving open-ended problems, and (2) subjects at high levels of curiosity tended to be able to all the sub-indicators of critical thinking skills. Subjects at a moderate level of curiosity tend to be less able to sub-indicators to use facts to be applied in concepts/formulas appropriately, draw initial conclusions in each step of completion, and work on problems with coherent steps. Subjects at a low level of curiosity tend to be unable to sub-indicators to use facts to be applied in concepts or formulas appropriately and tend to be less able to sub-indicators formulate problem questions, draw initial conclusions in each step of the solution, work on problems with coherent steps, and write down the steps to solve the problems that have been found.

1. Introduction

Mathematics is one of the subjects that has an important role for students. According to Pasani (2018), teaching mathematics at lower levels and middle classes such as in junior high school helps to guide students thinking more so when it comes to handling concrete to abstract ideas through the practice of solving daily math problems or others subject related to daily life. Rasiman (2013) revealed that the purpose of giving mathematics subjects to elementary and secondary level students is to prepare students to be able to face various changes in life that are always developing because mathematics can train students to act on logical, rational, critical thinking, careful, honest, efficient and effective. This can be said that the basis of critical thinking also has an important role for students.

Critical thinking is one aspect of the quality of educational attainment in the context of the nation's intellectual life and character development (Nio, Sukestiyarno, Waluya, Rochmad, Isnarto, & Manullang, 2017). It means that critical thinking is an important aspect of student learning achievement. However, two major international assessments assessing students' mathematical and scientific abilities, TIMSS (Trend in International Mathematics and Science Study) and PISA (Program for International Student Assessment) show that the ability to think critically mathematically in Indonesia is still low. This is shown by the results of Trends in International Mathematics and Science Study (TIMSS, 2015) which showed that in 2015 Indonesia was ranked 45th out of 50 countries with a score of 397 points for mathematics which meant that the mathematical abilities of students in Indonesia were in a low category. Also, according to the report The Organization for Economic Co-operation and Development or called the OECD (2018: 5) shows that the PISA results in 2015 about the mathematical abilities of students in

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Indonesia have not been satisfactory because the scores obtained by Indonesian students at PISA 2015 are only 386, whereas the 2015 PISA average score is 490.

Furthermore, the National Center for Education Statistics (2019: 282) revealed that PISA reported mathematical literacy in terms of six levels of proficiency, with level 1 being the lowest and level 6 being the highest. Students who score at levels 5 and 6 are considered to have the high ability because they have demonstrated advanced mathematical thinking and reasoning skills needed to solve problems of greater complexity. These results show that the percentage of 15-year-old students performing on the PISA 2015 mathematics literacy scale, by selected proficiency levels and education systems is 69% below level 2 while at levels 5 and 6 only 1%. In line with the 2015 PISA results, Setiawan (2014) classifies the ability level formulated in PISA with the level of thinking according to Bloom. Level 4 to level 6 in PISA is classified as high order thinking, while level 1 to level 3 is low order thinking. This means that based on the results of the 2015 PISA, most junior high school students in Indonesia are only able to do simple mathematical operations, this means junior high school students in Indonesia have not been able to achieve high order thinking.

Dinni (2018) states that what is meant by high order thinking skills includes problem-solving abilities, creative thinking skills, critical thinking skills, argumentative abilities, and decision-making abilities. In line with McMahon (2007) states that the process of high order thinking is an integration of critical thinking processes and creative thinking processes. That is, not achieving high order thinking skills in students indicates that students' critical thinking skills in junior high are also still low.

Based on the facts above, it is necessary to improve the quality of mathematics learning in Indonesia so that students' mathematical abilities, especially critical thinking skills, also increase. Syaban (2004) asserts that to improve mathematical abilities as expected, teachers must prepare and arrange learning strategies in the process of delivering mathematical material to students and teachers must have the skills to choose an appropriate learning model, both for the material or the situation and conditions of the learning. take place.

According to Kowiyah (2016), teachers can improve students' critical thinking skills with one of the strategies namely through the activities of asking open-ended questions to students or commonly referred to as the open-ended approach. The statement was corroborated by Prihartini, Lestari, & Saputri (2016) which revealed that one approach that can be used to improve students' mathematical critical thinking skills is the open-ended approach. This is because open-ended problems can stimulate important aspects of critical thinking, namely analyzing, rethinking, or generating new ideas. Based on these things it is clear that the provision of open-ended questions can support efforts to improve students' mathematical critical thinking skills.

The fact that was found during the observation activities related to learning in Semarang 30 Public Middle School on 29 July 2019 until 11 September 2019 shows that the critical thinking ability of students in Semarang 30 Public Middle School is still low. The low critical thinking ability of the students is indicated by the grade 7 daily test scores where the classical completeness is only 3% to 13% of the total students in each class. Even though the daily test questions consist of questions to measure students' critical thinking skills.

The reviews outlined above indicate that critical thinking skills are an important aspect that must be considered in the process of learning mathematics. But besides these aspects, other important aspects must be considered in the process of learning mathematics, namely the positive attitude or views of students towards mathematics. According to the Minister of Education and Culture's Regulation No. 81A on the Implementation of the General Lessons Guidelines Curriculum (2013: 40), one of the competencies that must be developed in learning activities is curiosity and the ability to formulate questions to form the critical thoughts needed to live smartly. This shows that curiosity is an important aspect that must be achieved by students in the process of learning mathematics.

Based on the above review, the ability to think critically mathematically and students' curiosity are important aspects of achieving the goals of mathematics learning.

The fact that there is a student at SMPN 30 Semarang related to the level of student curiosity based on the results of a questionnaire test tested for students of class VII D on 25 September 2019, shows that there are various levels of student curiosity that is high, medium, and low. This reinforces the reason for doing research related to students 'critical thinking skills in open-ended problems in terms of students' curiosity.

Based on the above background, the formulation of the problems examined in this study are (1) Is there an influence of curiosity on the critical thinking skills of Grade VII students of SMP Negeri 30 Semarang in solving open-ended questions ?; (2) How is the description of the ability to think critically mathematically in solving open-ended problems in terms of the level of curiosity of VII grade students of SMP Negeri 30 Semarang? So, the purpose of this study is to (1) Test the significant influence between curiosity on critical thinking skills of class VII students of SMP Negeri 30 Semarang in solving open-ended questions; (2) Describe the ability to think critically mathematically in solving open-ended problems in terms of the level of curiosity of class VII students of SMP Negeri 30 Semarang.

The hypothesis proposed in this study is that there is a significant influence between students' curiosity on the ability of open-ended critical thinking on the PBL-themed scaffolding strategy.

2. Methods

This study was a mixed-methods study with sequential explanatory design.. The population in this study were grade VII students of SMP Negeri 30 Semarang. Class VII D is given a mathematical critical thinking ability test in the form of open-ended questions that were previously tested in the test class VII Class A. To analyze mathematical critical thinking skills of students in solving open-ended questions in terms of the level of curiosity, the experimental class filled out a questionnaire that was created by the researcher. From the results of tests and questionnaires, researchers determine the research subjects to be interviewed. The mathematical critical thinking ability interview was conducted on 6 students consisting of 2 students at each level of high, medium, and low curiosity chosen by purposive sampling. The selection of subjects in this study was chosen from each of 2 students in each level of curiosity with the dominant level of critical thinking ability at each level of curiosity.

3. Results & Discussion

3.1. Data Analysis Quantitative Critical Mathematical Thinking Ability Test

In this study, a test was conducted to see the effect of the level of curiosity on students' mathematical critical thinking skills in solving open-ended problems.

Based on the results of statistical tests obtained by a simple linear regression equation, i.e $\hat{Y} = 21{,}4777 + 0{,}748X$ is linear and the coefficient of the direction of regression means, where X is the level of students' curiosity and Y is the ability to think critically mathematically students in solving open-ended problems. The SPSS output results indicate that the value r_{count} for the relationship X with Y is equal $0{,}663 > r_{table} = 0{,}3494$ it can be concluded that there is a relationship or correlation between curiosity on students' mathematical critical thinking skills in solving open-ended problems. Because r_{count} is positive, it means that the relationship between curiosity and students 'mathematical critical thinking skills in solving open-ended problems is positive or in other words increasing student curiosity will increase students' mathematical critical thinking skills in solving open-ended problems. This is supported by Solehuzain & Didayati (2017) research which shows that there is a significant influence on students' curiosity variables on students' mathematical abilities. In line with the results of research conducted by Hidayat (2016) which shows that there is a positive influence of student curiosity on student achievement.

3.2. Results and discussion of qualitative research

Qualitative data analysis in this study was carried out data reduction, data presentation, and concluding in advance. Data reduction begins with correcting the final test results, correcting the questionnaire of curiosity, and determining the subject to be interviewed. Data reduction was carried out on observations and interviews of research subjects by simplifying the two results into simple and neat language arrangements regarding the ability to think critically mathematically in solving open-ended problems.

Based on the results of a curiosity analysis of 32 students of class VII D of SMP Negeri 30 Semarang, there were 5 students with high levels of curiosity, 22 students with moderate levels of curiosity, and 5 students with low levels of curiosity . The selection of research subjects was chosen by each of the two students in each level of curiosity. Interviews were also conducted to find out the character of curiosity of students in-depth. The interview method is carried out with the main aim to strengthen the indicators of

the results of the test work but also to explore deeper the students' mathematical critical thinking skills in solving open-ended problems. The subjects chosen were then interviewed and analyzed. Based on the analysis of the results of the curiosity questionnaire, six research subjects were selected as listed in Table 1.

Table 1. Research subject

No	Subject	Code	Category
1	S-1	E-7	High curiosity
2	S-2	E-24	High curiosity
3	S-3	E-6	Medium curiosity
4	S-4	E-12	Medium curiosity
5	S-5	E-27	Low curiosity
6	S-6	E-28	Low curiosity

This section will discuss the description of mathematical critical thinking skills in solving open-ended problems in terms of students' level of curiosity. The results of the analysis of mathematical critical thinking skills in solving open-ended problems in terms of students' level of curiosity are presented in Table 2.

Table 2. Results of Analysis of Mathematical Critical Thinking Ability in Resolving Open-Ended Questions in Terms of Curiosity Level

Level of Curiosity	Sub-indicator						
	1	2	3	4	5	6	7
High	✓	✓	✓	✓	✓	✓	✓
Medium	✓	✓	✓	✓-	✓-	✓-	✓
Low	✓	✓-	✓	-	✓-	✓-	✓-

Information:
Sub-indicator 1 : Write down the information contained in the problem
Sub-indicator 2 : Formulate problem questions
Sub-indicator 3 : Find ideas/concepts that are relevant
Sub-indicator 4 : Use facts to be applied in concepts/formulas appropriately
Sub-indicator 5 : Draw the initial conclusions in each step of completion correctly
Sub-indicator 6 : Work on problems with coherent and correct steps
Sub-indicator 7 : Write down the solution of problems that have been found
✓ : tend to be able to
✓- : tend to be less able
- : tend to be unable

3.3. Description of Critical Mathematical Thinking Ability in Solving Open-Ended Questions in Terms of Curiosity Level

Based on table 2, subjects with a high level of curiosity tend to be able to all the sub-indicators of critical thinking skills. This is in line with Facione's opinion as quoted by Agoestanto, Sukestiyarno, Isnarto, Rochmad, & Permanawati (2019) which states that people who can think critically are ideal people who have high curiosity, extensive experience, full of confidence, open-minded, flexible, diligent in finding relevant information, and make sense in the selection criteria. It means that high curiosity is one of the things that indicates a person has the ideal critical thinking skills.

Based on the analysis of the final data, it is found that subjects with a high, moderate, and low level of curiosity tend to be able to work on the problems in the sub-indicator writing the information contained in the problem. The subject can work on problems for sub-indicators writing down the information contained in the problem because they are accustomed to working on the problem in which there are instructions about the indicator, where the intended instruction is to gather the information contained in the problem. This habit occurs because, in learning, students have often been trained in gathering information, so students are easy to work on problems in which there are sub-indicators writing down the

information contained in the problem. This is in accordance with Thorndike's theory of the law of training (law of exercise) according to Sugihartono as quoted by Ainia, Kurniasih, & Sapti (2012) in which states that the more often a behavior is trained, the stronger and more accustomed it becomes. In line with this fact, Larasati & Prihatnani (2018) states that a work that is done repeatedly, then the work that was initially difficult to do will be easier to do. These habits cause students to work on the problems on the sub-indicator of writing information contained in the problem. This is in line with the opinion of Ariyani (2014), the habit starts from the obligation that is carried out every day from the necessity of students to live it so that over time the child becomes able to do it.

Subjects with a high level of curiosity and are likely to be able to work on the problems in the sub-indicators formulate the problem questions. This is because they are accustomed to working on problems in which there are instructions about the indicator, where the intended instruction is to formulate the questions contained in the problem using their language. This is in line with the opinion of Sukmawati, Suarni, & Renda (2013), that an attitude formation process that is carried out permanently through repeated experiences to the stage of independence, is habituation. The habit that is done repeatedly in working on the problem causes students to work on the problems in sub-indicators formulating the problem questions. This habituation is in accordance with Thorndike's theory of the law of practice. While subjects with a low level of curiosity tend to be less able to work on the questions on the indicator formulating problem questions because the two subjects could not mention what was asked about the problem with their language completely. The inability of students to formulate questions will inhibit the ability of students to think critically mathematically in finding logical solutions to the problems given. This is consistent with the opinion of Ainiyah, Suyitno, & Winarti (2018) which states that critical thinking requires skills to recognize problems and formulate questions to find logical solutions.

In the sub-indicator find ideas/concepts that are relevant subjects with high, medium, and low levels of curiosity tend to be able to work on the problems on these indicators. This is because they are able and accustomed to determining the form of algebra in a problem.

In sub-indicators using facts to be applied in concepts or formulas precisely subjects with high curiosity tend to be able to work on problems in these sub-indicators. Whereas for subjects with moderate curiosity tend to be less able to work on problems in sub-indicators using facts to be applied in concepts or formulas appropriately and for subjects with low curiosity tend to be unable to work on problems in sub-indicators using facts to be applied in concepts or formula correctly. This is because the two subjects at the level of curiosity are not able to determine a lot of each coin which is the answer to problem number 1 point (d), while the two subjects at the level of curiosity low tend not to be able to find the correct answer to the number problem 1 and number 2 with sub-indicators use facts to be applied in concepts or formulas appropriately. Mistakes in subjects with a low level of curiosity are caused because he cannot interpret questions with indicators using facts to be applied correctly in concepts or formulas to problems. According to Haghverdi, Semnani, & Seifi (2011) states that students must have semantic knowledge, which is the knowledge that helps students to understand the purpose of the problem and interpret the problem correctly. The inability of subjects with a low level of curiosity in interpreting the problem correctly makes the answer proposed wrong. As for subjects with moderate levels of curiosity because students have difficulty in determining the numbers that meet the algebraic form equations that have been obtained.

Subjects with a low level of curiosity experience obstacles in the clarification stage because students tend to be less able to sub-indicators formulate problem questions. This results in students experiencing obstacles in the assessment and strategy stages that can be seen in the results of the analysis of mathematical critical thinking skills open-ended for a low level of curiosity that the subject tends to be unable to sub-indicators using facts to be applied to concepts or formulas appropriately and tend to be less able to sub-indicators work on problems with coherent and correct steps and write down the steps to solve the problems that have been found. Difficulties in the two stages of the assessment and strategy resulted in the subject also experiencing obstacles at the conclusion stage which indicated that the subject also tended to be less able to sub-indicators draw the initial conclusions in each step of completion correctly. This is confirmed by the research of Rochmad, Kharis, & Agoestanto (2018) which shows that if students in the clarification phase are blocked, it will hamper in the assessment phase; the strategy phase, and then the difficulty in the inference phase.

4. Conclusion

Based on the results of research and discussion, conclusions are obtained: (1) There is a significant influence between students 'curiosity on students' mathematical critical thinking abilities in solving open-ended problems; (2) The description of students' mathematical critical thinking skills in solving open-ended problems in terms of the level of curiosity is as follows. Subjects at all three levels of curiosity are able to sub-indicators write down the information contained in the problem and find ideas/concepts that are relevant. Subjects with a high level of curiosity and are able to sub-indicators formulate the problem questions and write down the steps to solve the problems that have been found. Subjects at a high level of curiosity are able to all the sub-indicators of critical thinking skills. Subjects at the level of curiosity are less able on sub-indicators to use facts to be applied in concepts/formulas appropriately, draw initial conclusions in each step of completion, and work on problems with coherent steps. Subjects at a low level of curiosity are unable to sub-indicators using facts to be applied in concepts or formulas appropriately and are less able to sub-indicators formulate problem questions, draw initial conclusions in each step of the solution, work on problems with coherent steps, and write steps solving problems that have been found.

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