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Analysis of mathematical reasoning ability of junior high school students of grade VII viewed from cognitive style on problem based learning with mind mapping

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Abstract

The method used in this research is a mixed method with the research design that is explanatory sequential design. The result of this research are (1) Mathematical reasoning ability of grade VII students after being given learning by using PBL with mind mapping reached minimal completeness criteria; (2) the description of students' mathematical reasoning ability with independent field cognitive style were capable to present mathematical statements, propose conjecture, do mathematical manipulation, give reason to solution, and draw conclusion; and (3) the description of students' mathematical reasoning ability with field-dependent cognitive style were capable to present mathematical statements, yet incapable to propose conjecture, FDK students were less able to manipulate mathematics, while FDL students were incapable to perform mathematical manipulation, provide reason for solution, and draw conclusions.

1. Introduction

Mathematics is a universal science which is useful for human life. It underlies the development of modern technology, and has an important role in various disciplines and advances the human mind. Rapid development in the field of information and communication technology today is based on the development of mathematics in the field of number theory, algebra, analysis, probability theory, and discrete mathematics. To master and create technology in the future, it takes mastery and understanding of mathematics strong from early (Kemdikbud, 2014). One of the goals of mathematics listed in Permendikbud Number 58 Year 2014 is to use reasoning in nature, manipulate mathematics both in simplification, and analyze the existing components in problem solving in the context of mathematics and others. In line with that, the aspects assessed in the mathematical assessment include comprehension, procedure, representation and interpretation, reasoning, problem solving and attitude (Kemdikbud, 2014). Based on the description, reasoning ability is one of the capabilities students must have in the mathematics learning process.

The term of reasoning is described by Copi (in Triastuti *et al.*, 2013) as a thought process to draw truth-based inferences (premises) that have been considered as true. Again, Mueller & Maher (in Agoestanto *et al.*, 2018) state that reasoning is a process that allows to review and rebuild previous knowledge in order to build new arguments. One of the mathematical abilities included in high-level mathematical thinking is the ability of mathematical reasoning (Adhi & Kusumah, 2017). The ability of mathematical reasoning is the ability to think or understand the problems of mathematics logically in order to obtain completion, sorting out what is important and not important in solving a problem that, and explain, or give the reasons for the settlement of a problem (Marsa *et al.*, 2014).

The indicator of mathematical reasoning ability formulated in technical explanation of Dirjen Dikdasmen Regulation No.506/C/PP/2004 cited by Ruslan & Santoso (2013) are (1) presenting mathematical statement orally, written, drawing, and diagrams; (2) filling a conjecture; (3)

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performing mathematical manipulation; (4) drawing conclusions, drawing up evidence, giving reasons or evidence against some solution; (5) drawing conclusions from the statement; (6) examining the validity of an argument; and (7) finding patterns or properties of mathematical phenomena to make generalizations. However, the indicators of mathematical reasoning ability used in this research are points (1) to (5).

In fact, Indonesia's junior high school students' reasoning ability still have low while Singapore's have high reasoning ability. The statement is proved by the analysis of Trends in International Mathematics and Science Study (TIMSS)'s results in 2011 which reports that the average percentage achieved by junior high school students in Indonesia in the cognitive domain at the reasoning domain level (17%) is far below the average the percentage of students in Singapore that reached 62% (Rosnawati, 2013). The average value of junior high students for mathematics subjects at the national examination year 2017 is 50.31 (Kemdikbud, 2017). This value is below the standard score set by BSNP of 55. In addition, Sulistiawati (2014) also argues that the percentage of junior high school students who are able to answer math reasoning issues correctly is only 14.29%.

According to Riyanto & Siroj (2011), one of the causes of the lack of reasoning ability and students' mathematics achievement is the process of learning conducted by teachers in the class which less involved students in the learning process or no discussion between students with students and students with teachers.

While developing the ability of mathematical reasoning, each teacher exposed students who have different characteristics between individuals with each other. The difference is due to differences in cognitive style. The cognitive style is a typical way of learning, both in terms of the reception and information management, attitudes toward information, and habits related to the learning environment (Alvani, 2016). Meanwhile, according to Rifqiyana (2015), cognitive style is also called as a style, not as a capability because it refers to the way a person processes information and solves a problem, rather than referring to how the best settlement process is.

Based on students' psychological differences in responding to their environmental situation, cognitive style is categorized into independent and dependent field of cognitive style (Usodo, 2011). Students with the cognitive style of Field Dependent (FD) tend to have difficulties in finding the relationship between information obtained and easily affected by the environment. Whereas, students with Field Independent (FI) of cognitive style tend not to have difficulties in finding a relationship between information obtained and not easily affected by the environment (Nuriana *et al.*, 2018).

One of learning models which can improve higher thinking skill and there is social interaction between teacher, student and problem is model of Problem Based Learning (PBL). Arends (2013) suggests that the PBL model is a learning approach in which students work on authentic issues with the intent to develop their own knowledge, develop inquiry and higher-order thinking, develop self-reliance and self-confidence. It is in line with Saputro *et al.* (2017) who state that PBL is appropriate in helping students become active learners because it puts learning in real-world problems and keeps students being responsible for learning. For more, Mikrayanti (2016) explains that problem based learning can improve the ability of mathematical reasoning. Furthermore, Buhaerah (2011) states that the model Problem Based Learning (PBL) is quite effective in improving students' reasoning skills.

Mathematical reasoning certainly requires a mature understanding of the concepts associated with the given problem. The concept required not only one, but some concepts. Mulyanah *et al.* (2013) state that mind mapping influences students' understanding of concepts. Primarily students make a mind mapping to summarize the material that will or has been taught. When making mind mapping, students carry out an act of thinking and writing. This explanation is in line with the opinion of Silaban & Napitulu (2012) who state that mind mapping can help students and teachers in the learning process in the classroom by summarizing the lesson materials into mind mapping sheets that are much easier to learn and remember by the students. This mind mapping activity is expected to help students to get the better understanding than taking notes in the usual way or reading too many books.

Regarding to the description above, there several objectives of this study, as follows (1) to know mathematical reasoning ability of grade VII students after being given learning using PBL with mind mapping reached minimal completeness criteria; (2) to describe the mathematical reasoning ability of junior high school students of grade VII which has independent field cognitive style; and

(3) to describe the mathematical reasoning ability of junior high school students of grade VII which has cognitive field dependent style.

2. Methods

The research method used was the combination method (mixed methods). The combination method design used was explanatory sequent design. The design began with quantitative data collection and then collected qualitative data to help explaining or elaborating on quantitative results (Creswell, 2014: 572).

The population in this study was the seventh grade students of SMP IT Permata Hati Banjarnegara in academic year 2017/2018. The sample used in this research was one class namely grade VII-C. The subjects consisted of 2 FI and 2 FD students. Further, the variables of this study were independent and dependent variable. The independent variable was a PBL learning model with mind mapping. The dependent variable was mathematical reasoning ability.

Data collection techniques of this study were observation, cognitive style classification test in the form of GEFT which was developed by Witkin *et al.* (1977), mathematical reasoning ability test, and interviews. The result of mathematical reasoning ability test was analyzed quantitatively by using right side proportion and average test with prerequisite test namely normality test. Furthermore, the qualitative analysis was conducted with triangulation technique that was data analyzed based on written test data, interview result, and triangulation.

3. Results & Discussions

Before being implemented learning in class VII-C SMP IT Permata Hati Banjarnegara, researchers tested the students' cognitive style classification using GEFT instrument. The results of the GEFT instrument filling analysis are presented in Table 1.

Table 1. Cognitive Styles of Class VII C SMP IT Permata Hati Banjarnegara

Cognitive Style	Amount	Percentage (%)
Field Independent	10	40
Field Dependent	15	60
Total	25	100

Based on the result of cognitive style, the four subjects of the study were SP-13 as Strong FI (FIK), subject of SP-09 as FI Weak (FIL), SP-20 subject as Strong FD (FDK), and SP-23 subject as FD Weak (FDL).

After a cognitive-style test, the next learning was done by using PBL with mind mapping of three meetings with a time allocation of 2 x 35 minutes per meeting. Then at the fourth meeting, the test of mathematical reasoning ability was held. The results of the mathematical reasoning ability test were tested by using the average test and proportion test. It reports that the average mathematical reasoning ability of students was more than 64 and the proportion of class VII students who obtained mathematical reasoning ability scores was more than 64 after being taught by using PBL with mind mapping was more than 75%. In other words, PBL model with mind mapping was one of the supporting mathematical reasoning abilities of students. This finding is in line with Mikrayanti (2016) who suggests that problem-based learning (PBL) can improve mathematical reasoning skills. Again, Buhaerah (2011) states that the Problem Based Learning (PBL) model is quite effective in improving students' reasoning abilities. Besides, this study also used mind mapping. The comparison of the average test scores of students' mathematical reasoning abilities who made mind mapping and not is presented in the following figure.

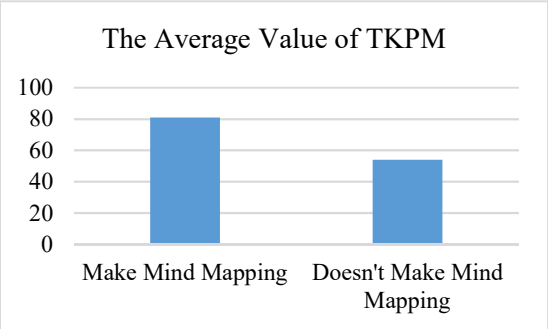

Figure 1. The Comparison of Student KPM Test Scores Average Based on Mind Mapping

Based on Figure 1, it is found that the average score of students' mathematical reasoning abilities who had made the mind mapping more than who did not make. It shows that mind mapping became one of the supporters of mathematical reasoning ability. The material that has been written in the form of mind mapping was applied when doing mathematical reasoning problem. As Mulyanah et

al. (2013) argue that mind mapping influences students' understanding of concepts.

3.1. Result of FI Students' Mathematical Reasoning Ability

The results of this study indicate that the mathematical reasoning abilities of FIK and FIL have similarities. Two FI subjects had similarities in the first indicator of presenting a mathematical statement. The subject of FIL was able to present the mathematical statement to the whole matter correctly. However, the subject of FIK was incomplete in presenting a mathematical statement on problem number 4 because of the given information about the problem. In general, the subject of FIK and FIL was capable of presenting mathematical statements. In other words, students who had cognitive style FI was able to present oral statements of math, writing, drawing, and diagrams. This is in accordance with Yekti *et al.* (2016) who suggest that the mathematical reasoning of subjects with FI cognitive style was able to identify problems by writing information obtained from the problem clearly and completely, describe the condition of the problem by using the image clearly and completely and well understand the purpose of the problem.

In addition, two FI subjects also had similarities in indicators suggesting allegations. The subject of FIL was able to put a good guess on the whole matter correctly. However, the subject of FIK was less precise in proposing strategies that will be used to solve at number 4. Otherwise, the subject of FIK was able to propose allegations/strategies on six other questions. In general, the subject of FIK and FIL was capable of submitting allegations. In brief, students who had cognitive style of FI was able to file allegations. This finding is in accordance with Haryanti & Masriyah (2018) who state that FI cognitive-style students were able to prepare allegations and prepare a settlement plan.

The third indicator was mathematical manipulation. Subject FIK was less able in solving the problem number 4. However, the subject of FIK was able to manipulate mathematics on six other questions. Meanwhile, the subject of FIL was able to manipulate the whole. In the whole, subject FIK and FIL were able to perform mathematical manipulation. So it can be said that students who have FI cognitive style were capable of manipulating mathematics. As Yekti *et al.* (2016) explains that subjects with FI cognitive styles are able to apply previously learned concepts to make new knowledge which is useful in achieving solutions. Again, Haryanti & Masriyah (2018) state that the cognitive style subject of FI is capable of implementing the plan.

The fourth indicator was to provide reasons for the correctness of the solution. The subject of FIK was incapable of providing a reason for the solution of number 6. However, the subject of FIK was able to provide a reason for the other six solutions. Meanwhile, the FIL subject was able to provide a reason for the overall solution of the problem. Overall, the FIK and FIL were able to provide a reason for the solution. Shortly, students who had FI cognitive style can provide a reason for the solution. This is in accordance with Haryanti & Masriyah (2018) who argue that the subject of FI is able to provide arguments before drawing conclusions.

The fifth indicator was to draw conclusions from the statement. Subject FIK was less able to draw conclusions about the numbers 4 and 6. Yet the subject of FIK was able to draw conclusions to five other questions. Then, the subject of FIL was less able to draw conclusions about the number 6 and able to draw conclusions to six other questions. Overall, FIK and FIL were able to draw conclusions. It can be concluded that students who had cognitive style of FI were able to draw conclusions from the statement. This is in accordance with Haryanti & Masriyah (2018) who explain that the subject of FI was able to make a logical conclusion.

3.2. Result of Mathematical Reasoning Ability of FD Students

The results of this study indicate that the mathematical reasoning abilities of FDK and FDL subjects have similarities and differences. Firstly, two FD subjects had similarities in the first indicator of presenting a mathematical statement. The subject of FDK and FDL were able to present the mathematical statement to the whole matter correctly. Eventually, students who have cognitive style FD was able to present the mathematical statement orally, writing, drawing and diagram. As Yekti *et al.* (2016) state that the mathematical reasoning of the subject with the cognitive style of FD is able to identify problems by writing down the information obtained from the problem clearly and completely.

The second indicator is to file a presumption. The subject of the FDK was able to file allegations on numbers 3 and 7, and less able to file allegations on questions 1, 4, 5, and 6. The

similarity of the subject of FDK and the subject of FDL to this indicator was incapable of presenting the number 2 Furthermore, the subject of FDL was less able to file allegations on numbers 1, 6, and 7. In addition, the subject of FDL was not capable of raising allegations on questions 3, 4, and 5. In general the FDK and FDL subject were less able to file allegations. In brief, students who have cognitive style FD were less able to file allegations. This is in accordance with Yekti *et al.* (2016) who suggests that the subject of the FD has not been able to submit a suspected settlement.

The third indicator is mathematical manipulation. The subject of FDK was able to manipulate the problem of number 3, less able to perform mathematical manipulations on questions 4, 5, 6, and 7, and not able to manipulate in question number 2. While the similarity of FDK and FDL subject to this indicator was performing manipulations on problem number 1. Furthermore, the subject of FDL was not able to do mathematical manipulation on the problem of numbers 2, 3, 4, 5, 6, and 7. Overall, subject FDK was less able to manipulate mathematics and subject FDL was not capable of performing mathematical manipulation. This is in accordance with Yekti *et al.* (2016) who state the subject of FD has not been able to apply the concept well.

The fourth indicator is to provide reasons for the correctness of the solution. The subject of FDK was able to provide a reason for the solution of the number 3. The similarity between the subject of FDK and the subject of FDL in this indicator ie was unable to give a reason for the solution of numbers 1, 2, 4, 5, 6, dan7. In addition, the subject of FDL was also unable to provide a reason for solution number 3. Overall, FDK and FDL were not able to give a reason to the solution. In brief, students who had cognitive style FD was unable to provide a reason for the solution. This is in accordance with Yekti *et al.* (2016) who explain that the subject of FD is incapable of providing logical reasons since it is less able to meet the second and third mathematical reasoning indicators.

The fifth indicator is to draw conclusions from the statement. The subject of FDK was able to draw the conclusion of the solution of the number 3, less able to draw the conclusion of the solution of numbers 1 and 6, and not able to draw conclusions about the numbers 2, 3, 4, 5, and 7. Meanwhile, the subject of FDL was less able to draw conclusions about number 1 and unable to draw conclusions about numbers 2, 3, 4, 5, 6, and 7. Overall, the FDK and FDL were incapable of drawing conclusions. Shortly, students who had cognitive style FD was not able to draw conclusions from the statement. This is in accordance with Yekti *et al.* (2016) who state that the subject of the FD is incapable of drawing any conclusions correctly since the subject of FD is less able to meet three previous mathematical reasoning indicators.

4. Conclusion

From the description of the analysis, there are several conclusion of the result that can be drawn, as follows (1) mathematical reasoning ability of grade VII students after being given learning using PBL with mind mapping has reached minimal completeness criteria; (2) description of students' mathematical reasoning ability with independent field cognitive style is capable of presenting mathematical statements, able to propose allegations, able to perform mathematical manipulation, able to give reason to solution, and able to draw conclusion; and (3) description of students' mathematical reasoning ability with field dependent cognitive style is capable of presenting mathematical statements, incapable of presenting allegations, FDK students are less able to manipulate mathematics while FDL students are unable to perform mathematical manipulation, unable to provide reason for solution, and not able to draw conclusions.

Besides, the researcher also give some suggestions in terms of the topic of this study, they are (1) PBL model with mind mapping can be implemented in mathematical learning on quadrilateral material and build flat side space to improve mathematical reasoning ability.; (2) students with different cognitive styles have different mathematical reasoning skills, so teachers are expected to use GEFT instruments to identify students' cognitive styles; and (3) teachers are expected to give more attention to students who have a field dependent cognitive style by getting used to working on mathematical reasoning questions. While students who have an independent field cognitive style are encouraged to take part in a math competition.

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