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ANALYSIS OF MATHEMATICS PROBLEM SOLVING ABILITY OF JUNIOR HIGH SCHOOL STUDENTS VIEWED FROM STUDENTS' COGNITIVE STYLE

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ABSTRACT

The process of thinking in solving problem needs teachers' attention to help students in developing problem solving ability. Problem solving ability in mathematics can be viewed from several dimensions, one of them is cognitive style. This study aims to analyze the students' problem solving abilities Field Dependent (FD), Field Intermediate (FDI), and Field Independent (FI). Type of the research is descriptive qualitative research. The cognitive styles of 27 students of class VIII G were determined using Group Embedded Figure Test (GEFT). Each category of cognitive styles was taken two students with the highest and lowest scores and were used as research subjects. Students of class VIII G were given lessons to introduce Polya problem solving steps and Problem Solving Tests (TPM). Students' answers in TPM were analyzed, and subjects were interviewed as triangulation. The results of students' problem solving were also analyzed to be given scaffolding. Weak FD (FDL) subjects had not been able to meet almost all indicators of problem solving. FDL subjects need guidance and more time to understand the information, but they had been able to connect mathematical knowledge to daily life. Strong FD (FDK) subjects got some constraints to use prerequisite knowledge, applied several appropriate strategies to solve problems, and reflected problem solving process using Polya steps. Problem solving ability of Weak FDI (FDIL) subjects and Strong FDI (FDIK) subjects were quite well. Most of problem solving indicators could be met by both subjects well. However, the two subjects could not arrange problem solving with different steps and not able to recheck the results of problem solving. Weak FI (FIL) subjects and Strong FI (FIK) subjects had good abilities in problem solving. Even FIK subjects were able to use problem solving strategies that had never been taught in school. FIL and FIK subjects got some constraints to make alternative answer of problem. FDK subject's ability increased after receiving scaffolding. FDK subjects were able to meet the indicators of problem solving though imperfect. Teachers should be able to create learning activities that are adjusted to the students' cognitive styles that students have good problem solving abilities.

Keywords: cognitive style, problem solving ability, problem solving

INTRODUCTION

Mathematics can not be separated from problem solving. The process of thinking in problem solving needs teachers' attention to help students in developing problem solving ability both in the context of the real world and mathematical context. Krulik and Rudnick (1995) defined problem solving ability as a individuals means in using the knowledge and capabilities that have been had previously to be synthesized and applied to new and different situations. According to the NCTM (2000), indicators of problem solving are: (1) building new mathematical knowledge through problem solving, (2) applying and adapting a variety of appropriate strategies to solve problems, (3) solving problems that arise in mathematics and in other contexts, and (4) monitoring and reflecting on the process of mathematical problem solving. Problem solving ability of students in Mathematics can be viewed from various dimensions, one of them is cognitive style. Cognitive style refers to someone's characteristic in responding, processing, storing, thinking, and using information to respond to a task or various types of environmental situations (Brown, et al, 2006; Kozhevnikov, 2007). Idris (2006) identified three types of cognitive style; they are Field Dependent (FD), Field Intermediate (FDI), and Field Independent (FI). FD individuals tend to work with external motivation, which is seeking guidance and instructions from others. FDI individuals tend to have the same ability as FD or FI students' because FDI is located between them. FI individuals view the problems analytically, are able to analyze and isolate the relevant details, detect patterns, and critically evaluate a problem (Yousefi, 2011).

Related to the background, some problems of the research are presented, they are: (1) How is students' mathematical problem solving ability in FD cognitive style in SMP 2 Kudus? (2) How is students' mathematical problem solving ability in FDI cognitive style in SMP 2 Kudus? (3) How is students' mathematical problem solving ability in FI cognitive style in SMP 2 Kudus? (4) How is students' mathematical problem solving ability after scaffolding?

METHODS

This research was descriptive qualitative. This study was conducted at SMP 2 Kudus. The research was carried out in VIII G class in the second semester of academic year 2013/2014. This study began with the determination of the student's cognitive style using Group Embedded Figure Test instrument (GEFT) and PBL lesson of volume and surface area of cubes and cuboid to accustom students in solving the problems using Polya steps. Each category of cognitive styles was taken 2 students with the highest and lowest scores to be research subjects. FD subjects with the lowest score were called Weak FD (FDL), whereas FD subjects with the highest score were called Strong FD (FDK). The same condition was also applied to the subjects with cognitive style of FDI and FI. FDI and FI subjects who got the lowest scores called Weak FDI (FDIL) and Weak FI (FIL), whereas FDI and FI subjects who obtained the highest score is called Strong FDI (FDIK) and Strong FI (FIK). The data in this study were collected directly by the researcher, so that the main instrument of this study is the researchers themselves who assisted with the aid of instruments; they were Problem Solving Test (TPM) and interview guides.

Data collection techniques that used in this study were test and non-test techniques. The techniques were used to obtain the results in completing the job of problem solving, while the non-test technique used interview method to obtain the data credibility. After the lesson, students with cognitive style FD, FDI, and FI were given TPM 1. In order to confirm the written test, interviews with the research subjects were conducted then scaffolding was given to the students who were on the Zone of Proximal Development (ZPD). After the scaffolding was given, the students were given TPM 2 which aimed to re-measure problem solving ability of students. TPM 2 questions were equivalent to TPM 1.

Data analysis was carried out before the field activity until the analysis stage during the field activity. The analysis before the field activity was done by validating the research device and instrument. Analysis on the field was a process of systematically searching and compiling the data obtained from TPM results and interviews. Data analysis was done by reducing the data (an activity that refers to the process of selecting, focusing, simplification, abstraction and transformation of raw data in the field), presenting the data (classifying and identificating the data, that is to write a collection of organized and categorized data so that it is possible to draw conclusions of the data), and drawing conclusions from data that has been collected and verifying the conclusions.

RESULTS AND DISCUSSION

The process of determining the subject of research by cognitive style using psychiatric tests developed by Witkin et al (1977); that is GEFT instrument. From 27 students of class VIII G, 13 students were on the cognitive style of FD, 8 students belonged to the FDI cognitive style, and 6 students were classified in FI cognitive styles. The results of students' cognitive style classification were used as the basic for making the discussion groups for each meeting. Each group consisted of students from the cognitive style of FD, FDI, and FI, so the groups were made up of a heterogeneous group of different cognitive styles.

The data of students' problem solving ability was the data of students' ability in solving mathematical problem by using Polya steps (Polya, 1973). Questions used were non-routine. Problems must be solved using Polya steps that should cover 4 aspects, (1) understanding the problem, (2) devising a plan, (3) carrying out the plan, and (4) checking and extending.

More detailed results of FD students' problem solving ability based on Polya steps are presented in Table 1.

Table 1. FD Students' Problem Solving Ability

No.	Indicator	FDL	FDK
1.	Understanding the problem	a. Able to write the information of the problems clearly but incomplete. b. Able to write the problems. c. Unable to create the perfect sketch.	a. Able to write the information of the problem completely and clearly. b. Able to write the problems. c. Able to create the perfect sketch.
2.	Devising a plan	a. Unable to write the formula that will be used properly. b. Unable to devise the problem solving plans correctly.	a. Unable to write the formula that will be used properly. b. Able to devise the problem solving plans correctly.
3.	Carrying out the plan	a. Unable to answer the problems correctly because they could not make the problem solving plans correctly. b. Unable to communicate the final conclusions.	a. Unable to answer the problems correctly because they could not make the problem solving plans correctly. b. Unable to communicate the final conclusions.
4.	Checking and extending	a. Unable to recheck their work. b. Unable to create another alternative answer.	a. Unable to recheck their work. b. Unable to create another alternative answer.

Subject FDL can not build new mathematical knowledge through problem solving. When FDL subjects faced a problem, subjects read it seriously. At first, subjects had not been able to understand the problems. However, when subjects were given guidance and opportunity to re-examine the problem, subjects were able to understand the information on the problem but it took a long time. FDL Subjects had not been able to utilize the information of the problems. Whereas, FDK Subjects differed from FDL subjects. FDK subjects could build new mathematical knowledge through problem solving. FDL and FDK subjects could not estimate problem solving strategies appropriately. Subjects were not able to use pre-existing knowledge to solve problems. However, the two subjects were able to link the knowledge of mathematics with everyday life correctly. For example, in question number 1, the question was the area of the painted monument was. Subject understood that the problem was the area of the surfaces. Both FD subjects were not able to apply the appropriate strategies to solve problems. Subject had not been able to reflect the process of solving problems well. This was proven by the problem solving process using Polya steps but this was imperfect. Problem solving ability of FDI students based on Polya steps are presented in Table 2.

Table 2. FDI Students' Problem Solving Ability

No.	Indicator	FDIL	FDIK
1.	Understanding the problem	a. Able to write the information of the problems completely and correctly. b. Able to write the problems clearly. c. Able to create the complete sketch but inexactly.	a. Able to write the information of the problems completely and correctly. b. Able to write the problems clearly. c. Able to create the complete sketch but inexactly.
2.	Devising a plan	a. Able to write the formula that will be used properly. b. Able to devise the problem solving plans correctly.	a. Able to write the formula that will be used properly. b. Able to devise the problem solving plans correctly.
3.	Carrying out the plan	a. Able to answer the problems correctly because they could make the problem solving plans correctly. b. Unable to communicate the final	a. Able to answer the problems correctly because they could make the problem solving plans correctly. b. Able to communicate the final

No.	Indicator	FDIL	FDIK
		conclusions.	conclusions of some problems.
4.	Checking and extending	a. Unable to recheck their work. b. Unable to create another alternative answer.	a. Rechecking their work inaccurately. b. Unable to create another alternative answer.

FDI subjects could build new mathematical knowledge through problem solving. Subjects understood the problems of a question quickly. Subjects were able to make a sketch of the problems but they did not pay attention to the length ratio so it was disproportional. Subjects were able to estimate precisely the problem solving strategies so that subjects could resolve the problem well. Subjects wrote problem solving strategies and the formulas that would be used. Subjects were able to employ pre-existing knowledge to solve problems in the mathematics context and the problems associated with everyday life. Figure 1 presents an example of the work of FDIL subjects in using Pythagorean formula to find the cubes height.

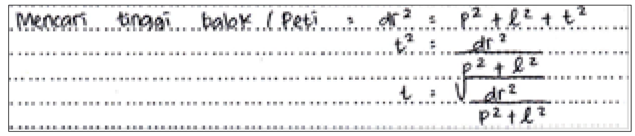

Figure 1. Example of the Work of FDIL Subjects

Subjects were able to examine and reflect the problem solving process although it was not perfect. This was proven by the problem solving process using Polya steps. In the final stage of Polya, subjects had not been able to do checking because of carelessness in the calculation and could not create other alternative answers.

Results of research on students' problem-solving abilities FI based on Polya steps are presented in Table 3.

Table 3. FI Students' Problem Solving Ability

No.	Indicator	FIL	FIK
1.	Understanding the problem	a. Able to write the information of the problems completely and correctly. b. Able to write the problems clearly. c. Able to create the sketch completely and appropriately.	a. Able to write the information of the problems completely and correctly. b. Able to write the problems clearly. c. Able to create the sketch completely and appropriately.
2.	Devising a plan	a. Able to write the formula that will be used properly. b. Able to devise the problem solving plans completely and well organized.	a. Able to write the formula that will be used properly. b. Able to devise the problem solving plans completely and well organized.
3.	Carrying out the plan	a. Able to answer the problems correctly because they could make the problem solving plans correctly. b. Able to communicate the final conclusions.	a. Able to answer the problems correctly because they could make the problem solving plans correctly. b. Able to communicate the final conclusions.
4.	Checking and extending	a. Able to recheck some problems completely. b. Unable to create another alternative answer.	a. Able to recheck their work correctly. b. Unable to create another alternative answer.

FI subjects could build new mathematical knowledge through problem solving. Subjects could understand the problem from a question quickly and appropriately. Subjects were able to estimate precisely the problem-solving strategies so that the subjects could solve the problem well. Subjects wrote problem solving strategies and the formulas that would be used to solve the problems. Even FIK subjects used a problem solving strategy which was not taught in school. Example of the work of FIK subject FIK was presented in Figure 2.

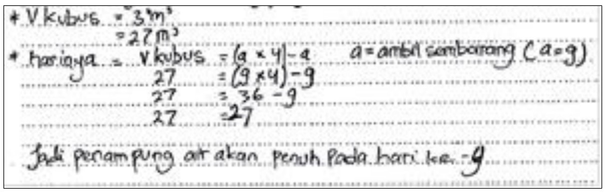

Figure 2. Example of Work of FIK Subject

In addition, FI subjects were able to use pre-existing knowledge to solve problems in the context of mathematics and the problems associated with everyday life. Subjects were able to examine and reflect the problem solving process although it was imperfect. This was proven by problem solving process using Polya steps. Subjects could perform stage 1 to 3 well, but at the final stage Polya subjects could not create another alternative answer to a problem.

Beside the above results, the other result of this study was problem solving ability of FDK subjects after scaffolding. From this result, it was given that the ability of FDK subjects was increased after scaffolding. More detailed results for problem-solving ability of FDK students after scaffolding would be presented in Table 4.

Table 4. FDK Students' Problem Solving Ability After Scaffolding

No.	Indicator		FDK
1.	Understanding the problem	a.	Able to write the information of the problems completely and correctly.
		b.	Able to write the problems.
		c.	Able to create the sketch correctly.
2.	Devising a plan	a.	Able to write the formula that will be used correctly but incompletely.
		b.	Able to devise the problem solving plans correctly.
3.	Carrying out the plan	a.	Able to answer some problems correctly, but the others were done inaccurately.
		b.	Able to communicate the final conclusions.
4.	Checking and extending	a.	Rechecking some problems.
		b.	Unable to create another alternative answer.

According Guisande (2007), the characteristic of FD subjects was they could not explain the complex informations into some parts. Research subjects who were classified into FD cognitive style could not understand the problem well. The information contained on the problems could not be understood and utilized by subjects. After reading repeatedly, FD subjects finally could mention what were given but did not understand the point. FD individuals were not selective in understanding information and tend to be influenced by external cues. Mulyono (2012) also argued that FD subjects tend to be difficult to determine the simple part of the original context or easily influenced by the manipulation of outwitted elements on the context because they viewed it globally. FD subjects had difficulties to analyze the pattern into different parts that were used to solve the problem.

According to Ngilawajan (2013), subjects with score 10-18 on the GEFT test belongs to FI cognitive styles. FI subjects could process information well than FD subjects. This study was not in line with it. FDI Subjects in this study were subjects who obtained score 10-13. FDI subjects could understand the problems well. FDI subjects could use the information to devise the problem solving correctly. FDIL and FDIK subject's ability has a little difference. FDIL subjects could not communicate the final conclusions while FDIK subjects could communicate the final conclusions for some problems. This strengthened Khoiriyah, Sutopo, and Aryuna's research (2013) showed that the category subjects with the same cognitive style do not always have the same thinking level as well.

Subjects of FI category were able to understand the problems well. This strengthens Muhtarom research (2012) which stated that FI subjects clearly wrote what was asked, they could easily and correctly write down what were given, they could create the link between what was given and what was asked to solve the problem. Mathematical problem solving required analytical ability of problem solvers. FI subjects were able to solve analytical problems better. This was in line with Yunos' opinion (2007) which stated that FI students more analytical in processing complex information, while FD students were more likely to use visual approach more globally.

CONCLUSION

FDL subjects had not been able to meet almost all indicators of problem solving. FDL subjects needed guidance and a long time to understand the information, but they were able to correlate mathematical knowledge to everyday life. FDK subjects constrained to use pre-existing knowledge, apply various appropriate strategies to solve problems, and reflect the process of problem solving using Polya steps. FDIK and FDIL problem solving ability were quite well. Most of the indicators of problem solving could be met by both subjects well. However, the two subjects could not develop problem solving with different steps and could not able to recheck the results of problem solving. FIL and FIK subjects had good problem solving abilities. Even FIK subjects were able to use problem solving strategies that had never been taught in school. FIL and FIK subjects met problems to make alternative answer from a problem. FDK subject's ability had increased after receiving scaffolding. FDK subjects were able to meet the problem solving indicators though imperfect.

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