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STUDENTS' DIFFICULTIES IN SOLVING RATIO PROBLEM

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Abstract
The concept of ratio is fundamental in mathematics and in many other fields of knowledge. For example, the use of ratios concept in deciding price per item, fractions, percentages, probability, problems in motion, measurement, enlargement and reduction of shapes, figures, and many other topics. However, results of TIMSS in 1999, 2003, and 2011 showed about 70% of ratio problem cannot be solved by Indonesian students. The importance of ratio in daily life bring difficulties in solving ratio problem such big matter. This research is descriptive qualitative and is to describe types and reasons of students' difficulties as well as the scaffolding given to overcome the difficulties of Indonesian students while solving ratio problem. The written test of ratio problem to 30 students of class 8K in SMPN 1 Sidoarjo is to determine 3 research subjects which has lower score than the first quartile of total score with different pattern of error. 3 subjects selected were interviewed to gain the information about students' difficulties types and factors. Students' difficulties were analyzed from students' answer sheets in solving ratio problem based on Polya problem solving. Scaffolding was given to overcome the difficulties with provision of Anghileri scaffolding in level 2 and 3; reviewing, restructuring, explaining, and developing contextual thinking. According to the research result, 16.67% of students were having difficulties in reading only (RD), 33.33% students were having difficulties in mathematics only (MD), and 50% of students were having difficulties in mathematics and reading (MDRD). Reason of students' difficulties in reading difficulties (RD) is error in understanding the information; in mathematics difficulties (MD) is inaccurate calculation; and in mathematics and reading difficulties (MDRD) are unable to recall the proportional relation and impulsive answer.
Keywords: Students' difficulties, mathematics difficulties, ratio problem.

INTRODUCTION

International assessments results of mathematics such as PISA and TIMSS show that only 1% of Indonesian Junior High School students reached level 3 of PISA and the one who reach Advanced and High Benchmark of TIMSS is lower than international average (Wulandari & Jaelani, 2015). This low performance indicates that many students have difficulty in solving mathematical problems. Silver (2009) defined a problem generally as a situation in which a goal is to be attained and a direct or usual route to the goal is blocked. Polya (1973) declared 4 steps of problem solving; understanding the problem, devising a plan, carrying out the plan, and looking back.

Students' mathematics difficulties, in cognitive aspect) can be investigated from the pattern of errors made by students while solving mathematical problems as results of miscalculation and erroneous procedure, calculating and reading skills (Rumasoreng and Sugiman, 2014; Kereh, et al., 2013; Karimah and Fuad, 2016). Some reason that influenced students' difficulties in solving mathematical problem are inaccurate calculation, transformation error of the given condition, poor number sense, error in understanding the information and the working memory deficit and inability to understand the given problem or recalling the mathematics concept related to the problems (Wulandari, 2015; Kereh, et al., 2013; Chan and Ho, 2010). According to its causes, mathematics difficulties are divided into 3 kinds; mathematics difficulty only (MD), reading difficulty only (RD), and mathematics and reading difficulty (MDRD) (Hanich and Jordan, 2001; Wulandari, 2015). So, whenever students have difficulties in solving mathematical problem, the difficulties will be able to be investigated from the pattern of error made by students in each step of their problem solving.

One topic that indicates the mathematics difficulty is ratios. Ratio is a comparison of two numbers, magnitudes, quantities or expressions, such as a measure of the relative size of two classes (Chaim, et. al, 2012; Livy and Herbert, 2013). The result of TIMSS in 1999, 2003, and 2011 shows that about 70% of problem on ratio and proportion in TIMSS can't be solved by Indonesian students and brought the students in the category of lower than international average (Ekawati et al. 2015). Ekawati,

et. al (2015) explained that one problem that students experienced challenges was "*Alice can run 4 laps around a track in the same time that Carol can run 3 laps. When Carol has run 12 laps, how many laps has Alice run*. In solving the problem, only 34% of Indonesian students' answer was correct and brought Indonesia to score lower than International average. Pattern of error made by students in each step of their problem solving in solving ratio problem can be used to investigate students' difficulties in solving ratio problem. According to (Chaim, et al., 2012) in solving ratio problem, students mostly difficult to decide the proportional relation of information in the given problem and difficult to transform the information into mathematical form.

In order to overcome the difficulties, Denyer (2009) stated that scaffold the learning in the classroom to encourage deep learning will improve students' ability in solving ratio problem. Scaffolding is the process that enables a students to solve a problem, carry out a task, or achieve a goal which would be beyond his unassisted efforts (Bakker & Smit, 2015; Wood et al., 1976). According to Anghileri (2006), there are 3 levels in scaffold the mathematics learning; The 1st level is environmental provisions (classroom organization), the 2nd level is explaining (convey concepts learned by students), reviewing (refocus students' attention and help them reach their own understanding) and restructuring (consolidate students' understanding to make ideas more accessible and take meanings forward), and the 3rd level is developing conceptual thinking (guide the student to focus on strategies or processes that can be used to solve the problem).

METHODOLOGY

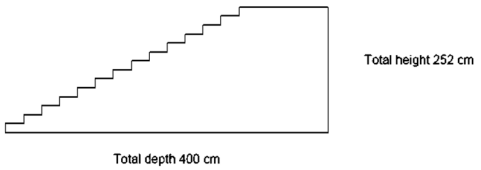
This research is a descriptive qualitative research which is to describe types of students' difficulties, reasons that influence the difficulties, as well as the scaffolding to overcome the difficulties. Written test of ratio problems is given to 30 students of class 8K SMPN 1 Sidoarjo in order to determining research subjects. 3 research subjects were selected using criteria as follow:

1. Students who got lower score than the first quartile of total score (26.3).
2. Students with different pattern of error. Patterns of error were seen from different score for each of students' answer (3 points for correct answer, 1 point for wrong answer, no point for blank answer).

Test of Ratio Problems

Problems used were taken from PISA and TIMSS items which consists of 3 numbers of problems; 2 problems adapted from PISA ratio problems with different category (algebra and geometry), and 1 problem adapted from TIMSS ratio problems. Those problems were consulted to the supervisor and tested to a student. Those 3 problems are as follow:

1. Peter bought 70 items and Sue bought 90 items. Each item costs the same and the items cost $800 altogether. How much did Sue pay? *(TIMSS 2011 Grade 8 Released Items)*
2. The diagram below illustrates a staircase with 14 steps and a total height of 252 cm.



What is the height of each of the 14 steps? *(PISA 2006 Released Items)*

3. Justin, Samantha and Peter ride bicycles of different sizes. The following table shows the distance their bicycles travel for each complete turn of the wheels.

	Distance travelled in cm					
	1 turn	2 turns	3 turns	4 turns	5 turns	6 turns
Peter	96	192	288	384	480	…
Samantha	160	320	480	640	800	…
Justin	190	380	570	760	950	…

Peter's bicycle has a wheel circumference of 96 cm (or 0.96 m). It is a three-speed bicycle with a low, a middle and a high gear. The gear ratios of Peter's bicycle are: Low 3:1; Middle 6:5; High 1:2. How many pedal turns would Peter take to travel 960 m in middle gear? Show your work. **NOTE: A gear ratio of 3:1 means 3 complete pedal turns yields 1 complete wheel turn.** *(PISA 2012 Released Items).*

Interview

Subjects selected were interviewed to gain the information about types of students' difficulties and reasons that influence the difficulties. Interview process was conducted by giving the problem to the student and did some questions and answer to the student. Questions that were being asked is to gain the information about kind of students' difficulties and reasons that influence the difficulties. Based on interview data analysis of Miles and Huberman (1994), the result analysis was done by data reduction, data display, and drawing and verifying conclusion.

Scaffolding

Scaffolding was given to students, right after researcher conduct the interview as the solution from researcher to overcome the difficulties of students. scaffolding used in this research refers to the Anghileri scaffolding in level 2 and level 3; reviewing, restructuring, explaining, and developing contextual thinking. Table below shows the terms of scaffolding.

Table 1. Terms of Scaffolding Given

Students' Difficulty	Activity	Kind of Scaffolding
Understanding the Problem	Ask the student to read the questions carefully and slowly	Reviewing
	Aske the student to reread the problem by emphasizing intonation on sentences that provide important information	Restructuring
	Ask the student to search for information contained in the question (what is given and what is the question)	Reviewing
	Explain to the student the way to bring out the given and question into mathematical model	Explaining
Devising a Plan	Remind the student of previous concepts that is related to solve the problem	Restructuring
	Guide the student to focus on strategies or processes that can be used to solve the problem	Developing Conceptual thinking
Carrying out a Plan	Do some question and answer to guiding the student solve the problem	Restructuring
	Ask the student to connect the related-previous concept to solve the problem	Developing Conceptual thinking
Looking back	Ask the student about the reason of her/his answer	Reviewing
	Ask the student to check her/his computation	Reviewing
	Ask the student to check her/his answer and the problem that being asked	Reviewing

RESEARCH RESULT AND DISCUSSION

This research was done in one class SMPN 1 Sidoarjo on 3rd - 4th of January, 2018. On 3rd of January, 2018, students were given mathematics test of ratio problems in 1 hour long to get the research subjects. In the next days, students were interviewed to gain the information about kind of difficulties and reason that influenced the difficulties. Right after the interview conducted, researcher did scaffolding to overcome difficulties of students.

Encoding types of student difficulties is presented in the table below:

Table 2. Students' Difficulties Indicator

Problem Solving Steps	**Indicators**	**Mathematics Difficulty**	**Code**
Understanding the Problem **(U)**	Error in transforming the information from the problem to mathematical form.	Mathematics Difficulties **(MD)**	MDU
	Unable to understand and stating the question of the problem.	Reading Difficulties **(RD)**	RDU-1
	Unable to understand and stating the given condition of the problem.	Reading Difficulties **(RD)**	RDU-2
Devising a Plan **(D)**	Unable to relate the given condition and question of the problem and does not have any idea to solve the problem	Mathematics and Reading Difficulties **(MDRD)**	MDRDD-1
	Error in relating the given condition and question of the problem or decide the wrong idea to solve the problem	Mathematics and Reading Difficulties **(MDRD)**	MDRDD-2
Carrying out the Plan **(C)**	Having trouble in calculating (miscalculation), computing (miscomputation), or constructing the given data to solve the problem correctly.	Mathematics Difficulties **(MD)**	MDC
Looking Back **(L)**	Inabilities in rechecking the calculation and reexamining the result and the	Mathematics Difficulties **(MD)**	MDL

Problem Solving Steps	Indicators	Mathematics Difficulty	Code
	path that led to it.		
	Inabilities in rechecking the read the problem and reexamining the result and the path that led to it.	Reading Difficulties **(RD)**	RDL

Result of Mathematics Test of Ratio

By accumulating the score to the scale of[0,100], the result of the test showed that 8 students scored < 26.3; 8 students scored < 53; 7 students scored between 53 and 74; and 7 students scored higher than 74 (including 2 students who scored the maximum score). The pattern of error was seen in the students' answer sheets for each step of problem solving and was sign as score; 3 for the correct step, 1 for the wrong step, and 0 for the blank step. Three students with initial AD, CSDSP, and MBFZ, scored less than the first quartile and were selected as research subject with different pattern of error in solving the problems. AD scored 21 (later named as RS2), CSDSP scored 8.77 (later named RS1) and MBFZ scored 8.77 (later named RS3). Table below show the score of each subject in solving 3 problems:

Table 3. Result of Mathematics Test

Sub	Number of Problem																		
	1							2				3							
	G	G	G	Q	DC	DC	L	G	Q	DC	L	G	G	Q	DC	DC	DC	L
RS1	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	1
Total	2							2				1							
AS	8.77																		
RS2	0	0	0	0	0	0	1	0	0	0	1	3	3	3	1	0	0	0
Total	1							1				10							
AS	21																		
RS3	0	0	0	0	0	1	0	0	0	3	0	0	1	0	0	0	0	0
Total	1							3				1							
AS																			

AS: Accumulated Score to the scale [0,100]
G: Given
Q: Question
DC: Devising and Carrying Out
L: Looking Back

To describe the kind of difficulties, reason that influenced the difficulties, and the scaffolding given to overcome the difficulties, researcher conducted an interview to every subject selected.

Interview Result of RS1

1. In solving problem 1, the difficulties occur in understanding the problem, devising a plan, and carrying out the plan. RS1 **kinds of difficulties** in solving problem 1 are reading difficulties (RD), mathematics difficulties (MD), and mathematics and reading difficulties (MDRD). **Reasons that influence** of RS1 in reading difficulties (RD) is because of error in understanding the information, in mathematics difficulties (MD) is her inaccurate calculation, and in mathematics and reading difficulties (MDRD) is inability to understand the given problem or recalling the proportional relation related to the problems. **To overcome the difficulties** of RS1, the scaffolding given were; reviewing by asking RS1 to search for information contained in the question, explaining by explaining to RS1 the way to bring out the given and question into mathematical model restructuring by reminding RS1 of previous concepts that is related to solve the problem, and developing contextual thinking by guiding RS1 to focus on strategies or processes that can be used to solve the problem. Here are the answer of RS1 after scaffolding:

2. In solving problem 2, the difficulties occur in devising and carrying out the plan. RS1 **kinds of difficulties** in solving problem 2 are mathematics difficulties (RD), and mathematics and reading difficulties (MDRD). **Reasons that influence** RS1 in mathematics difficulties (MD) is her inaccurate calculation and in mathematics and reading difficulties (MDRD) is inability recalling the proportional relation related to the problems and impulsive answer or without prohibition in solving the problems. **To overcome the difficulties** of RS1, the scaffolding given were; restructuring by reminding RS1 of previous concepts that is related to solve the problem and developing contextual thinking by guiding RS1 to focus on strategies or processes that can be used to solve the problem. Here are the answer of RS1 after scaffolding:

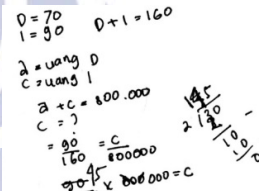


Figure 1.1 Result of RS1 After Scaffolding

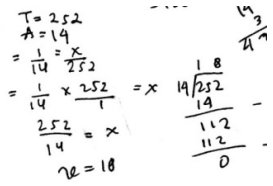


Figure 1.2 Result of RS1 After Scaffolding

3. In solving problem 3, the difficulties occur in understanding the problem, devising a plan. RS1 **kinds of difficulties** in solving problem 3 are reading difficulties (RD), and mathematics and reading difficulties (MDRD). **Reasons that influence** of RS1 in reading difficulties (RD) is error in understanding the information, and in mathematics and reading difficulties (MDRD) is inability to understand the given problem or recalling the proportional reasoning (multiplicative relation) related to the problems and impulsive answer or without prohibition in solving the problems. **To overcome the difficulties** of RS1, the scaffolding given were; reviewing by asking RS1 to search for information contained in the question, explaining by explaining to RS1 the way to bring out the given and question into mathematical model restructuring by reminding RS1 of previous concepts that is related to solve the problem, and developing contextual thinking by guiding RS1 to focus on strategies or processes that can be used to solve the problem. Here are the answer of RS1 after scaffolding:

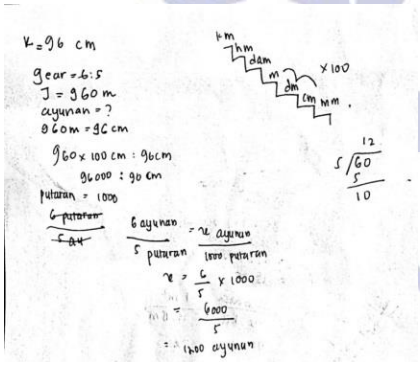


Figure 1.3 Result of RS1 After Scaffolding

Interview result of RS2

1. In solving problem 1, the difficulty occurs in devising a plan. RS2 **kind of difficulties** in solving problem 1 is mathematics and reading difficulties (MDRD). **Reasons that influence** of RS2 in mathematics and reading difficulties (MDRD) are inability to recalling the proportional relation related to the problems and impulsive answer or without prohibition in solving the problems. **To overcome the difficulties** of RS2, the scaffolding given are; restructuring by reminding RS2 of previous concepts that is related to solve the problem, and developing contextual thinking by guiding RS2 to focus on strategies or processes that can be used to solve the problem. Here are the answer of RS2 after scaffolding:

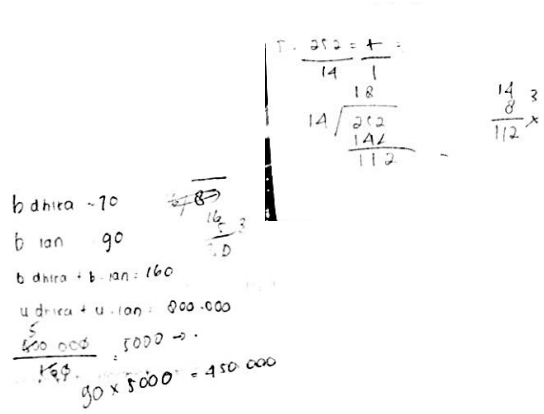


Figure 1.4 Result of RS2 After Scaffolding

2. In solving problem 2, the difficulty occurs in devising a plan. RS2 **kind of difficulties** in solving problem 2 is mathematics and reading difficulties (MDRD). **Reasons that influence** of RS2 in mathematics and reading difficulties (MDRD) inability to understand the given problem or recalling the mathematics concept related to the problems and impulsive answer or wi**. To overcome the difficulties** of RS2, the scaffolding given were; restructuring by reminding RS2 of previous concepts that is related to solve the problem, and developing contextual thinking by guiding RS2 to focus on strategies or processes that can be used to solve the problem. Here are the answer of RS2 after scaffolding:

Figure 1.5 Result of RS2 After Scaffolding

3. In solving problem 3, the difficulty occurs in devising a plan. RS2 **kind of difficulties** in solving problem 3 is mathematics and reading difficulties (MDRD). **Reasons that influence** of RS2 in mathematics and reading difficulties (MDRD) inability to understand the given problem or recalling the proportional relation relate swer or without prohibition in solving the problems. **To overcome the difficulties** of RS2, the scaffolding given are; restructuring by reminding RS2 of previous concepts that is related to solve the problem, and developing contextual thinking by guiding RS2 to focus on strategies or processes that can be used to solve the problem. Here are the answer of RS2 after scaffolding:

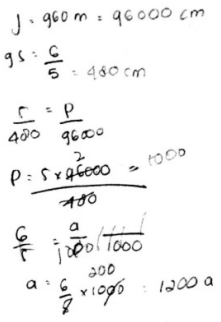


Figure 1.6 Result of RS2 After Scaffolding

Interview Result of RS3

1. In solving problem 1, the difficulty occurs in devising and carrying out the plan. RS3 **kinds of difficulties** in solving problem 1 are mathematics difficulties (MD) and mathematics and reading difficulties (MDRD). **Reasons that influence** of RS3 in mathematics difficulties (MD) are inaccurate calculation and in mathematics and reading difficulties (MDRD) inability to understand the given problem or recalling the proportional relation related to the problems, impulsive answer or without prohibition in solving the problems. **To overcome the difficulties** of RS3, the scaffolding given are; restructuring by reminding RS3 of previous concepts that is related to solve the problem, and developing contextual thinking by guiding RS3 to focus on strategies or processes that can be used to solve the problem. Here are the answer of RS3 after scaffolding:

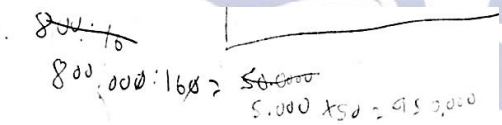


Figure 1.7 Result of RS3 After Scaffolding

2. In solving problem 2, the difficulty occurs in devising a plan. RS3 **kind of difficulties** in solving problem 2 is mathematics and reading difficulties (MDRD). **Reasons that influence** of RS3 in mathematics and reading difficulties (MDRD) are either inability to recalling the proportional relation related to the problems and impulsively solving the problems. **To overcome the difficulties** of RS3, the scaffolding given is restructuring by reminding RS3 of previous concepts that is related to solve the problem. Here are the answer of RS3 after scaffolding:

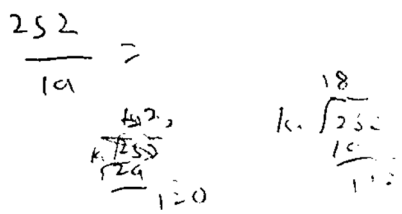


Figure 1.8 Result of RS3 After Scaffolding

3. In solving problem 3, the difficulty occurs in devising a plan. RS1 **kind of difficulties** in solving problem 3 is mathematics and reading difficulties (MDRD). **Reasons that influence** of RS3 in mathematics and reading difficulties (MDRD) are inability to recalling the proportional relation related to the problems. **To overcome the difficulties** of RS3, the scaffolding given are; restructuring by reminding RS3 of previous concepts that is related to solve the problem, and developing contextual thinking by guiding RS3 to focus on strategies or processes that can be used to solve the problem. Here are the answer of RS3 after scaffolding:

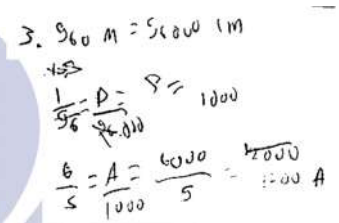


Figure 1.9 Result of RS3 After Scaffolding

According to the data in solving 3 problems, 3 students have difficulty in mathematics and reading difficulty (MDRD) due to inability to recall the proportional relation of each information given in the problem; 2 subjects have difficulty in mathematics difficulty (MD) due to error in calculation; and 1 subjects have difficulty in reading difficulty (RD) due to error in understanding the given information in the problem. This research result is in line with (Hanich and Jordan, 2001) that mostly students have difficulties in mathematics and reading difficulties (MDRD) and mathematics difficulties only (MD), and students with MD usually perform better mathematics result than MDRD.

CONCLUSION AND SUGGESTION

Conclusion

Based on the analysis research result and discussion in Chapter IV, the conclusion about "Students' Difficulties in Solving Ratio Problem" including kinds of difficulties, reason of students' difficulties, and the solution to overcome the difficulty are described follows:

1. Kind of difficulties of subject 1 are RD, MD, and MDRD; kind of difficulties of subject 2 are MDRD; and kind of difficulties of subject 3 are MD, and MDRD. From the result, 16.67% of students were having difficulties in reading only (RD), 33.33% students were having difficulties in mathematics only (MD), and 50% of students were having difficulties in mathematics and reading (MDRD).

2. Reason of students' difficulties in reading difficulties (RD) is error in understanding the information; reason of students' difficulties in mathematics difficulties (MD) is their inaccurate calculation; and reasons of students' difficulties in mathematics and reading difficulties are unable to recall the proportional relation and impulsive answer.
3. The scaffolding given to overcome the difficulties in reading only are *reviewing, restructuring,* and *explaining*; the solution (kind of scaffolding) to overcome the difficulties in mathematics only (MD) is *restructuring*; and the solutions (kinds of scaffolding) to overcome the difficulties in mathematics and reading are *developing contextual thinking and restructuring*.

Suggestion

For teachers, students' difficulties are able to be identified by looking at their pattern of error in solving the problems. By understanding kinds and reason of students' difficulties, students will understand the material better. Students' difficulties in solving ratio problem can be overcome by giving scaffolding of level 2 and 3; *reviewing, restructuring*, and *explaining* when the students have difficulties in understanding the problem; *restructuring and developing contextual thinking* when the students have difficulties in devising and carrying out the plan; and *reviewing* when students have difficulties in checking their work.