Classification of Students’ Non-Routine Problem Solving Skills

A A A Sita Pramayudi, IGP Sudiarta, and IWP Astawa

Mathematics Department, Faculty of Mathematics Natural Science
Universitas Pendidikan Ganesha, Bali-Indonesia, 81116

Email : ayusita1410@gmail.com

Abstract. Non-routine mathematical problems are complex problems that require a level of creativity and uniqueness in solving them. Classification students’ characteristics of solving non-routine problems have not been many researchers who provide an overview. This study aims to classify the characteristics of students’ problem solving skills. This type of research is a qualitative study involving five students of class VIII at SMP Negeri 1 Kintamani. Five students were selected through a purposive sampling technique on the condition that students of class VIII have high, medium and low mathematical skills. Data regarding non-routine mathematical problem solving students are collected through problem solving tests and supported by interview tests to obtain a picture of students' ability to understand the questions along with an understanding of the answers that have been done. Data were analyzed with data reduction, data presentation, and data verification steps. Data that has been verified are analyzed using the constant comparison method. Characteristics of non-routine mathematical problem solving students can be classified into 4 levels, namely Level 1 (students' understanding of problems along with mathematical problem solving is very lacking), Level 2 (Students' understanding of problems less and students' problem solving is lacking but able to plan problem solving), Level 3 (students 'understanding of problems takes a long time and students' problem solving is good), and Level 4 (students 'understanding of problems is good and students' problem solving is very good). Classification is obtained based on reference to problem solving according to Polya.

1. Introduction

Problem solving is a step where students use their knowledge, ability to understand problems, and understand to meet the demands of unusual situations [1]. Solving problems means students face new situations that must be understood they can find right steps to solve them [2].

Non-routine mathematical problems are a type of problem that emphasizes the development of problem solving skills, reasoning skills, and use of skills in real situations [3]. Non-routine problems focus on assessing and understanding problems that are higher than use of steps (algorithms) that are often used to solve problems [4]. Students use more reasoning skills to understand problems so that they can find solutions from non-routine problems encountered.

Non-routine problem solving has same solving steps with routine problems, but in solving non-routine problems students are required to use more reasoning skills in order to understand the problem information properly [5].

Research on solving non-routine mathematical problems has been carried out. One of them is research conducted by Yazgan (2010) [6] regarding use of non-routine problem solving strategies in first grade. The results of this study indicate that use of problem-solving strategies succeed in first grade in which students can understand the form of non-routine problems and has a significant relationship with students’ scores and students' mathematics achievement. Subsequent research conducted by [7] regarding development of non-routine mathematical problems in the assessment of students'
mathematical literacy. This study shows that non-routine problem solving influence the students’ ability to understand the situation in our daily lives better.

Many studies on mathematical problem solving have been carried out and have shown good results, but it does not include how the characteristics of students’ problem solving. Characteristics of students problem solving can provide special characteristics of how students solve non-routine problem.

Much research has been done regarding identification of students' mathematical skills. Research conducted by Siswono 8 on level of students’ creative thinking in mathematics classrooms shows that students’ creative thinking skills have 5 levels and each level has its own characteristics that distinguish it.

Subsequent research conducted by Siswono (2018) regarding profile of students' reasoning skills in solving mathematical problems gives results that students' reasoning skills have a category in solving problems 9. The categories obtained in this study are high ability, moderate ability, and low ability. Research on characteristics of student problem solving has also been carried out, one of which is the research conducted by 10. The research resulted that students could be classified into 2 namely students with good problem solving and students with ordinary problem solving.

Based on the description above, many studies have been conducted on the characteristics of student problem solving and showing students' success in solving mathematical problems. However, research on the classification of the characteristics of students' mathematical problem solving has not been done. Characteristics of problem solving gives teacher information on characteristics of students 'mathematical problem solving makes teacher easily known how the students' ability to solve mathematical problems.

2. Research method
This type of research is qualitative research. Qualitative research is a research method based on post positivism philosophy, used to examine natural object conditions, where researchers are key instruments. The research subjects were VIII grade students of SMP Negeri 1 Kintamani who were selected through a purposive sampling technique. The subjects in this study consisting of 5 people who were coded with S1, S2, S3, S4, and S5. The subjects were selected on the condition that students’ have high, medium, and low mathematical skills.

The instrument was a test of non-routine mathematical problems and interview guidelines. Data collection techniques in this study used non-routine mathematical problem solving tests and in depth interview. Data analysis was carried out with the model of Miles and Huberman. Data analysis with data reduction, data display, and conclusion drawing / verification. Classification of students’ non-routine mathematical problems solving using constant comparison analysis 11.

3. Result and discussion
In this study, data retrieval was done by giving a test in the form of non-routine mathematical problem also conducted interviews with students regarding the completion of the non-routine mathematical problems given. Students are given 2 tests to check the validity of student answers. If the answers of first test and second test have the same characteristics, the answers given by students are valid and can be used in this study.

The questions given to students are as follows.
"For rock concerts, a rectangular field measuring 100 meters long and 50 meters wide is prepared for visitors. Tickets were sold out and even many fans stood up. If there are many spectators standing by one third of the audience sitting, what is the number of visitors to the concert? 13

Students are given tests twice with a different time span between first test and second test. First test is held on April 16, 2019 and second test is held on May 7, 2019 with the same students and similar types of questions. The results of the test answers that have been carried out by students are outlined below.
3.1. Results of answers and S1 interviews

The results of interviews with students are as follows.

P : Do you understand the problem?
S1: I understand a little, but I need to read it several times
Q : What are the steps to completion?
S1: I first looked for the area of the field according to the information contained in the question. After that, I asked for 1/3 because there was information on the question, many viewers stood 1/3 of the spectators who were seated. That way the standing audience is the field area multiplying 1/3 and the audience sitting into the field area multiply by 2/3.

P : Are you sure of the answer?
S1: I am sure, I have worked on the information in the question and already according to my formula.

P : in your opinion, the answer you get is relevant to the intent question?
S1: I think so

Translation:
1) Known : length = 100
   Width = 50
   Asked : a visitor……?
   Answered : area = length x width
   = 1/3 x 5000 = 1666,6
   = 2/3 x 5000 = 3333,3
   = 4999,9

Figure 1. Answer S1 for the first problem number 1

S1 answers the question with the correct first step. S1 is able to use question information well and is able to understand the usefulness of the information provided. However, student answers are not correct. Students conclude that the answer obtained by multiplying the area of the field by 1/3 is the intended answer. However, in the questions that were asked were many spectators who stood and those who sat. That way, the answers obtained by students are in the form of a broad section of the field while the ones asked in the questions are many spectators.

3.2. Results of answers and S2 interviews

The results of interviews with students are as follows.

Q : Do you understand the problem well?
S2: I think I understand the problem, but I need to read it repeatedly.
Q : What about your answer?
S2: I answer the question by looking for the width of the field first. After obtaining the area of the field, I proceeded to find many standing spectators by multiplying the area of the field by 1/3 and many spectators sitting by multiplying the area of the field by 2/3. That way there were many standing spectators and many spectators sitting.

Q : Are you sure of your answer?
S2: I am sure of my answer because it is in accordance with the information on question.
Q : Do you think your answer is in accordance with the question?
S2: in my opinion it is appropriate because of the information on the questions and how to do it I am right.
Translation:

1) Known: length = 100 meters
   Width = 50 meters

Asked: many visitors?
Answered: area = length x width
   = 100 m x 50 m = 5000 m

5000 x 1/3 = 1666,6
5000 x 2/3 = 3333,3
1666,6 + 3333,3 = 4999,9

Figure 2. S2's answer for the first try number 1

S2 works on the problem using the information on the question well. S2 is able to use question information to find the width of the field and use the wide field results to find many spectators by multiplying 1/3. The results obtained by S2 in this step are part of the field and not the number of spectators.

3.3. Results of answers and S3 interviews

The results of interviews with students are as follows.

Q : Do you understand the problem?
S3 : I understand a little about the problem, so I repeat it several times read the question.

Q : Which part do you not understand in the problem?
S3 : I don't understand the audience information that stands 1/3 of the audience who sat down

P : Do you not think about the steps to solve it?
S3 : I didn't think about it, I could only search to the extent the field is because that information is what I understand.

Q : Do you think this problem is difficult?
S3 : I have never worked on this problem, so in my opinion it is rather difficult

Q : After working on this problem is there a shadow to work on the problem this type again?
S3 : maybe

Translation:

1) Length = 100 meters
   Width = 50 meters

Area = length x width
   = 100 x 50
   = 5000

Figure 3. S3's answer for the first try number 1

S3 can use part of the information in the question so that the student's work is only partially. S3 feels that he doesn't understand the problem so he can't continue his work. S3 said that he had never worked on this type of problem so that it can be seen that students lack training in working on the problem of the story. That way, students feel troubled in finding answers to questions of this type.

3.4. Results of answers and S4 interviews

The results of interviews with students are as follows.

Q : Do you understand the problem?
S4 : I understand a little about the problem

Q : Which parts are not understood?


S4: I don't understand the information that many viewers stand one third of the audience sitting.

Q: In the answer sheet do you get a lot of audience? Is that already correct?

S4: Yes, I wrote that there were many viewers watching the concert as much as 5000. Because according to the information the question is known as width and length field, so it's multiplied and gets 5000 results. Then a lot the audience is 5000.

P: Is it possible to measure the width and length of the field like it can accommodate 5000 people?

S4: Maybe.

Translation:
1) Length = 100 meters
    Width = 50 meters
    Area = length x width
    = 100 x 50
    = 5000 people

Figure 4. Answer S4 for the first issue number 1

S4 works on the problem using the information he knows and concludes according to his understanding. S4 works on the problem until it gets results from the field and concludes that many viewers are the same as the field. S4 solved the problem according to his understanding of the problem. In the execution of the question students have difficulty in understanding the problem, it is seen that students read the questions many times and require quite a long time.

3.5. Results of answers and S5 interviews

The results of interviews with students are as follows.

Q: Do you understand the problem?
S5: I don't know what the question means.

P: Which part do you not know?
S5: I'm all confused, I can only understand the numbers.

P: Why is your answer like that?
S5: I only see the numbers, because there are 100 and 50 so I am multiply and I see 1/3 then I multiply the product for 3.

Q: Why do you multiply the number in the question?
S5: Yes, I just thought so.

Q: Do you remember the formula for finding the area of a rectangle?
S5: No, I forgot.

Q: Why are you multiplying 3?
S5: Because it is questioned there is a number 3 so I immediately divide 3.

P: Why do you divide it instead of reducing or multiplying or add it?

S5: Because I only thought of that.

Translation:
1) 100 x 50 = 5000
   5000 : 3 = 1100

Figure 5. S5's answer for the first issue number 1
The S5 works on the problem takes quite a long time. S5 is difficult to understand and difficult to use mathematical concepts in working on problems. S5 looks confused after reading the questions and only understands the numbers contained in the question. With the numbers contained in the S5 problem multiplying the numbers on the question without understanding the purpose of the number.

Therefore, through the characteristics found in the process of solving mathematical problems students can be categorized into several levels of problem solving skills. The translation of the level according to the characteristics is as follows.

| Level   | Characteristics of the Problem Solving Level |
|---------|---------------------------------------------|
| Level 4 | Students understand the intent of the problem and can plan the solution well. Students solve problems in accordance with the completion plan that has been made. Students adjust the answers that have been obtained with the questions. Students have strong motivation in working on problems and have a great desire to solve problems. Students have ideas in solving the questions given. Students do not need a long time to work on the questions. |
| Level 3 | Students don't understand the questions well. Students are able to use information on questions to solve problems but not in accordance with the problem. Students have ideas to solve problems even though they have not fully understood the problem. Students have motivation in solving the questions given. The ideas in solving the problem are still lacking, but the students' efforts in finding the ideas are already good. Students need some time to work on the questions. |
| Level 2 | Students don't understand the questions well. Students use information on the question but are still mistaken in its use. Student motivation in solving problems is still lacking. Students' efforts in solving problems are still lacking so students cannot find a solution to the problem. Students need a fair amount of time to work on the questions. |
| Level 1 | Students do not understand the problem well. Students have no motivation or good effort in solving problems. Students' understanding of the material is very lacking. Students need a long time to work on the questions. |

4. Conclusion
Based on the formulation of the problem, the results of data analysis, and the discussion of research that has been described can be concluded that solving non-routine mathematical problems have their respective characteristics. The non-routine mathematical problem solving characteristics of students can be classified into several levels. The classification is: level 4, level 3, level 2, and level 1 with the characteristics of each at each level that gives a picture of solving non-routine mathematical problems of students at each level. The classification of characteristics at each level refers to problem solving according to Polya.

The characteristics obtained in this study have several similarities. The categories found in this study have similarities and are related to the categories of research conducted by Upu (2003)\textsuperscript{14}. The comparison between the categories in this study and in the research conducted by Upu (2003) is as
follows: level 4 is related to good category, level 3 is related to moderate category, level 2 with less category, level 1 with very less category

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