Students' Problem Solving Ability in Non-routine Geometry Problem

Fajri Maulana and Novia Tri Yuniawati

***Abstract*—Problem solving is one of four abilities which has been emphasized in the 21st century. A problem type engaged to explore students' problem solving ability is non-routine problem, particularly topic geometry. This research aims to describe students' problem-solving. It is a descriptive study using qualitative approach. The result indicated that the high - ability subject was quite able to understand the task and look back the results. In addition, upon preparation and execution of the plan, subject was able to do well. The medium-ability subject was able to plan properly, despite quite capable of understanding the problem, carry out the plan and looking back her result. The low-ability subject figured out the problem quite well, yet during plan preparation, plan execution, and reviewed the work, subject performed adequately. It is necessary for teacher to train and familiarize the students in solving non-routine problem hence the students can experience their own mathematical process.**

***Index Terms*—Problem solving, non-routine problem, geometry**

I. Introduction

In this 21st century, the educator expects that mathematics learning can explore 4C skills, which include communication, collaboration, *critical thinking and problem solving*, and creativity and innovation. One of which that seems difficult to overcome is critical thinking and problem solving. Critical thinking is required by students to solve problems and develop their HOT skills [1]. In addition, problem solving activities are needed to allow students to build their own knowledge and experience in math [2].

Many teachers try to encourage students' problem-solving skills by presenting open-ended problem [3], [4]. This is sometimes called a non-routine problem, as it is rarely applied in learning. Non-routine problem is a problem that is not directly determined the methods in solving it. It takes a reasonably mature thinking process, thereby students will grasp the purpose of the problem given [5]. Integrate problem solving in geometry learning has a significant role, those are improved reasoning competence, be more critical toward the problem, and skilled in solving geometry problems [6]. Teaching programs should enable students to use visualization, spatial reasoning and geometric modeling in solving problems [7].

MTs. is acronym of Madrasah Tsanawiyah. It is one type of junior high school education level that is managed under the auspices of the religious department. MTs. Islamiyah Wongsorejo is located in Wongsorejo, Banyuwangi. According to one of the MTs. Islamiyah mathematics teacher, the students in this school rarely solve tasks of problem-solving type or exploration, they are more often working on a short answer problem.

One of the classes that categorize excellence is Grade 8A. But, according to the teacher, the problem-solving skills of Grade 8A students still need to be improved. Therefore, the researcher wanted to analyze problem solving skills of the students of Grade 8A, which aims to describe and know which process/step students need to be improved by the teacher.

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II. Methods

This research is descriptive study with qualitative approach. Data collection engaged test and interviews. The test used is an open-ended problem-solving test on real issues related to geometry. The interviews conducted are unstructured interviews. The determination of research subjects is based on the one of students' daily score and their communication skills. The daily score is used to categorize the students with high, moderate, or low mathematical skills using classification as seen in Table I below [8];

TABLE I: Categorization of Subjects

Score (s)	Category
$s \geq (\bar{x} + DS)$	High
$(\bar{x} - DS) < s < (\bar{x} + DS)$	Medium
$s \leq (\bar{x} - DS)$	Low

where;

s: score of daily test

$\bar{x}$: mean

DS: standard of deviation

The information related to student communication skills discussed with the teacher in order to facilitate the interview.

Subjects of this study at least three students of grade 8A MTs. Islamiyah Wongsorejo, comprised of students with high, medium, and low mathematics skills. This research is stopped if the subjects are able to pass the Polya's problem solving step either in writing or even interview.

Data analysis is through several processes; (1) transcription of interview result, (2) reviewing written results and the interview along with notes in field, (3) data reduction, (4) categorization based on Polya's problem-solving steps includes 4 steps; *understand the problem, devise a plan, carry out the plan, and look back* [9], (5) analyzing, and (6) summing up [10].

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III. Result

The results below are descriptions of the student worksheets. The description is based on the steps of Polya's problem solving.

A. High-Ability Subject (ST)

Based on Fig. 1 below, it can be seen that the work of the ST was very short and dense. On understanding the problem stage, ST did not write down the problem main idea. Furthermore, ST did not write down the questions asked and the information presented to lead to the solution. At the stage of devising a plan, ST showed only a single step that would be used, conversion. No other systematic steps were planned. At the stage of executing the plan, ST converted the unit and then explored calculation of important points. However, calculation results were not correct. Finally, in looking back stage, ST did not possess the conclusions, even though ST presented a representation of the solution in the form of a sketch. It also did not present other possible solutions.

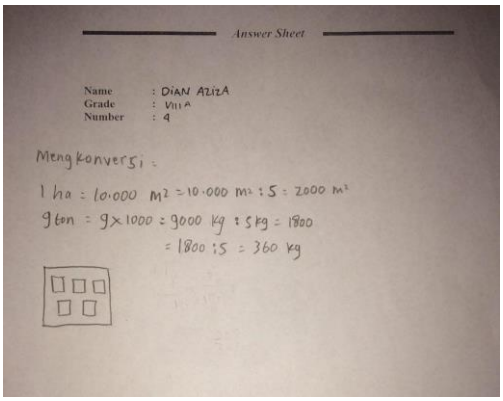

Fig. 1. The answer sheet of ST.

B. Medium-Ability Subject (SD)

According to Fig. 2 below, it can be seen that it looks twice the process down but produces the same answer. In understanding the problem, SD showed important parts of the problem, however, the subject did not write down what was being asked. In addition, SD did not write the information of the problem on the worksheet. SD did not show the writing plans/steps systematically that she would conduct. However, she was able to carry out the plan by calculating the important things she got right away. On the stage of looking back, no conclusions were presented, even though the picture presented was proper enough to examine the questions. In addition, nor presented other solutions.

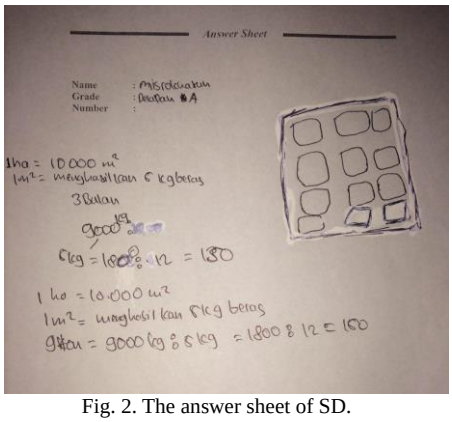

Fig. 2. The answer sheet of SD.

C. Low-Ability Subject (SR)

Fig. 3 shows us that in understanding the problem, the important things about the problem were not presented. The question was not written. Similar to another subject, the information on the problem was also not presented. In devising a plan, there was no systematic process take place that she might conduct. Subject directly performed the calculation process (carry out the plan) of her thought which results were almost right. SR completed the problem very briefly and presented without review (look back) process, whether in the form of conclusions or other solutions.

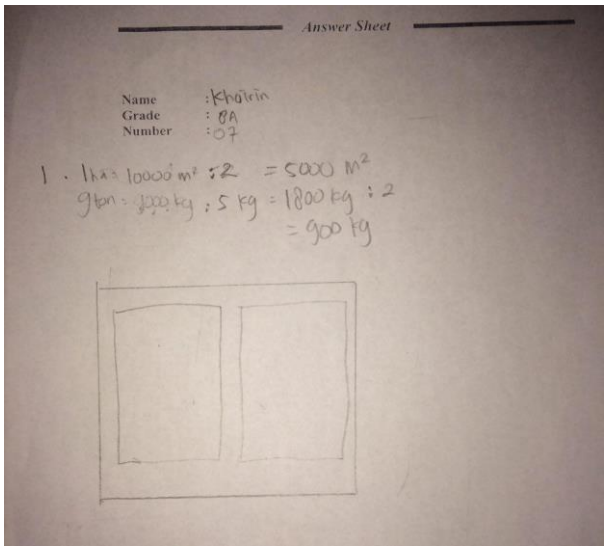

Fig. 3. The answer sheet of SR.

IV. Analysis and Discussion

The analysis below is the results of interviews associated with the student worksheet. The interviews are the results that have been reduced and selected according to the Polya's problem solving steps.

A. High-Ability Student (ST)

1) Understanding the problem

At the stage of understanding, ST did not write down the main points of the problem, the questions asked, and the information. However, when interviewed, ST was able to declare these things,

Teacher	*From the problem, what is known?*
ST	*The land is one hectare. 1 m^2 equal to 5kg in 3 months. 9 tons in 3 months.*
Teacher	*Then, what things are unknown or asked?*
ST	*How many rice fields for up to 9 tons*
Teacher	*Did you write down the information of the problem?*
ST	*No Ma'am, because it's there so I do not write again.*

ST did not write, because she thought it already exists on the problem. Hence, she immediately did the calculation. From this, it can be seen that the understanding of ST is adequate, because the information in the problem should also be written and understood to lead her to the solution.

2) Devise a plan

In Fig. 4 we can see that ST only showed one step, which is to convert/change unit.

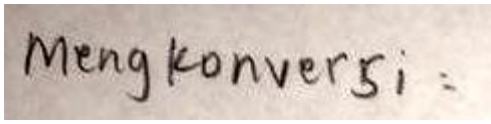

Fig. 4. The first plan of ST.

But, when she was being interviewed by the teacher, ST stated that after changing the unit she directly did the calculation and drew the sketch.

Teacher	*After knowing the important things of the problem, what steps will you do to go to the solution?*
ST	*Change the unit, calculate, and draw.*

ST just writes down the convert steps, since the calculation and drawing steps do not need to be written first. Therefore, we can see that ST is generally good at devising a plan, as she was able to explain the steps that she would have performed to find a solution.

3) Carry out the plan

In carry out the plan, Fig. 5 and Fig. 6 tell us that ST showed two process of conversion.

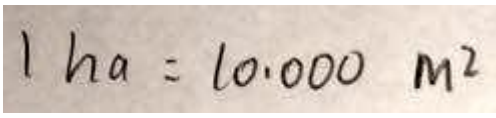

Fig. 5. The first conversion of ST.

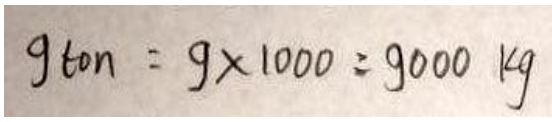

Fig. 6. The second conversion of ST.

This is also supported from the interview result, as follows;

Teacher	*From the steps you are planning, how do you carry out the first steps?*
ST	*1 hectare equals to 10.000m^2, then 9 tons equals to 9x1000 = 9000kg.*

The next step is to calculate, Fig. 7 shows that ST did the calculation even if there is 1 count that is not used.

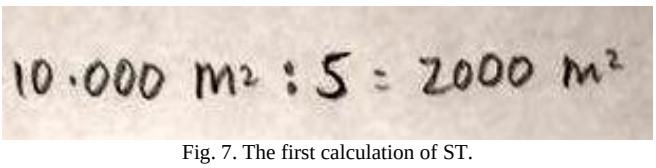

Fig. 7. The first calculation of ST.

Based on Fig. 7, it generates something that ST did not understand. Next, ST performed twice division on Fig. 8 and Fig. 9.

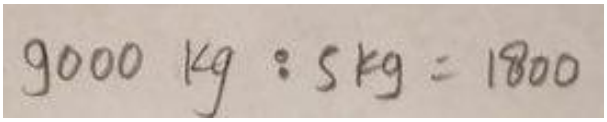

Fig. 8. The second calculation of ST.

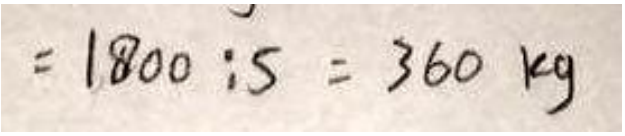

Fig. 9. The third calculation of ST.

This interviews support those results,

Teacher	*Then how to the next step?*
ST	*I counted from 10000 divided by 5 is 2000. Then 9000 divided by 5 is 1800. The last, 1800 divided by 5 is 360. So the rice fields are 5, aren't they?*
Teacher	*Why 10000 divided by 5?*
ST	*Because I want to make 5 fields.*
Teacher	*Then, what is the difference with 9000: 5?*
ST	*9000: 5 is sum of rice produced by each field.*
Teacher	*Then, why 1800 should be divided by 5?*
ST	*I mean 1800 is the width of the rice field we need, then it divided by 5 so that each field has 360m^2 area.*
Teacher	*So, 10000 divided by 5 was not used?*
ST	*Not Ma'am. A wrong counting.*
Teacher	*Well, why are you drawing sketch of rice fields?*
ST	*As a command, ma'am.*

Based on the interviews above, ST was able to show a sketch on Fig. 10 that states her final solution in accordance with the commands in the task.

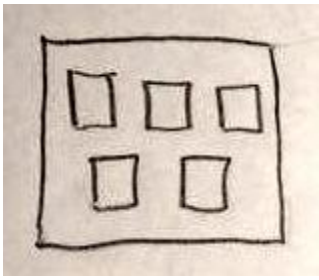

Fig. 10. The sketch of ST.

From the results above we can see that ST is able to carry out all the plans. In addition, ST is also able to know the error that she did. Thus, we know that in the stage of carrying out the plan ST can be categorized well.

4) Look back

At the stage of looking back, there was no conclusion or other solutions were presented within her worksheet. But, ST was able to explain the conclusions and miscalculations she made after looking back the problem. The results can be seen from the following interviews;

Teacher	*From your calculations, what can be concluded?*
ST	*The number of rice field is five and its size is 360m^2*
Teacher	*From the information, what rice field should be shaped?*
ST	*Square ma'am.*
Teacher	*What kind of fields do you have?*
ST	*It is squares, ma'am.*
Teacher	*If your rice field size is 360m^2, what size of each side?*
ST	*60 x 60 Ma'am, I think I am wrong. 60 x 6 right?*
Teacher	*That! Is 60 x 6 the size of square?*
ST	*No, ma'am, OK, I'm wrong*
Teacher	*Then, is there any other solution you wrote down?*
ST	*No, Ma'am.*
Teacher	*Why?*
ST	*Because I think my answer is enough.*

From these results, ST is quite able to look back at what is on the matter. So that she can annul his error, because she does not read clearly the information on the problem.

B. Medium-Ability Subject (SD)

1) Understanding the problem

At this stage, SD was able to show important things from the problem, it can be seen on Fig. 11;

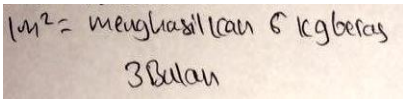

Fig. 11. The important things of SD.

This is also supported by the following interviews;

Teacher	*From the problem, what are you getting?*
SD	*Land 1 hectare, then 1m^2 produces 5kg of rice for 3 months and 9ton of rice that expected.*
Teacher	*Then, what is unknown from the problem?*
SD	*The number of rice fields needed, ma'am.*
Teacher	*There is information on the problem, isn't it? Why do you not write it down?*
SD	*Because I think it's just calculating.*
Teacher	*But, do you understand that information?*
SD	*Not Ma'am. I just read the problem.*

The issue of SD is she does not read the information. She personally has directly to do the calculation once after finishing reading the problem. From the transcription above, we can see that SD is enough in understanding the problem. Since, SD has not read and write down the information that exists for the problem where it is important as well.

2) Devise a plan

In devising a plan, there is no plan/step that will be done. But, SD was able to explain her plan when interviewed,

Teacher	*Well, from your work. Can you tell me about your steps?*
SD	*Change the unit, divided the gain by 5. Then divided again by 12 and draw a sketch.*

From the above, it can be seen that SD is able to state well every step that will be done. Although, the step is less clear.

3) Carry out the plan

In carrying out the plan, SD shows the process that begins by changing the units as seen in Fig. 12 and Fig. 13 below;

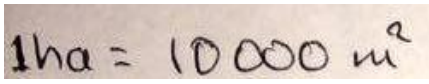

Fig. 12. The first conversion of SD.

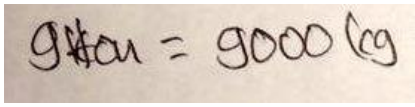

Fig. 13. The second conversion of SD.

That process is done because she memorized. This is supported by the following interviews;

Teacher	*From the steps you mentioned earlier, Please, Explain, how to change the units?*
SD	*1 hectare equals to 10000 m^2, then 9 tons equals to 9000 kg.*
Teacher	*How did you know to change that unit?*
SD	*I remembered Ma'am.*

The next step is doing the calculation as seen in Fig. 14 below.

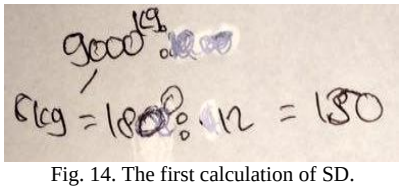

Fig. 14. The first calculation of SD.

SD performs twice the same calculation as seen in Fig. 15,

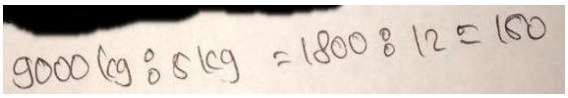

Fig. 15. The second calculation of SD.

The above calculation process is supported by interview results as follows.

Teacher	*Ok, then the second step divided by 5, what does it means?*
SD	*9000 divided by 5 is equal to 1800.*
Teacher	*Where 5 from is?*
SD	*From that 1m^2 produce 5 kg's Ma'am.*
Teacher	*Then, you divided again by 12, why 12?*
SD	*Because I want to make 12 rice fields, Ma'am.*
Teacher	*From dividing by 12, what do you get?*
SD	*The size of each rice field is150.*
Teacher	*Then, what are you doing?*
SD	*Drawing the sketch of rice fields in the land.*

From the interviews, SD determined the number of rice fields based on her want, it is not based on the situation/information on the problem. The next step is drawing a sketch as a representation of the solution as seen on Fig. 16 below;

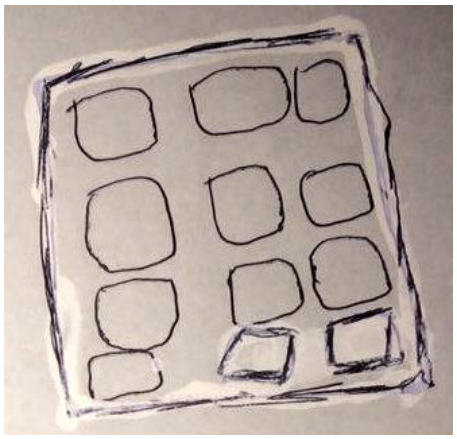

Fig. 16. The sketch of SD.

From those results above, in this stage, SD was able to execute the important things that exist even though there is a lack of understanding because the information in the problem is not read so that the result is inappropriate. Therefore, in this stage SD has enough ability.

4) Look back

At the stage of looking back, there is no conclusion and any other solutions are written down. But, while in the interviews the subject was able to conclude the solution that she got along with her mistake. In addition, she was able to explain the reason why she wrote the counting twice,

Teacher	*From the results you get, what can be concluded?*
SD	*The number of rice field is 12.*
Teacher	*Try it now to read the information on the problem. What do you get?*
SD	*The rice field should be square and the size may be different.*
Teacher	*Well, what about your results?*
SD	*My rice field has the same size.*
Teacher	*Is it square?*

SD	*No Ma'am.*
Teacher	*Why?*
SD	*Because the size is 150. So I am wrong, am not I?*
Teacher	*Then, is there any other solution you serve?*
SD	*No, ma'am.*
Teacher	*Why?*
SD	*Because that is divisible by 1800.*
Teacher	*From your worksheet, why is it done twice?*
SD	*For better writing ma'am.*

From the results, we can see that SD is quite capable of looking back at her work, so that she understand where her mistake.

C. Low-Ability Subject (SR)

1) Understanding the problem

At this stage, the subject does not write down the important things about the problem. But, subjects were able to explain when in the interviews.

Teacher	*After you read the problem, what are the important things do you get?*
SR	*The land area is1 hectare and 9 tons of rice is expected. Then 1m^2 area can produce 5kg.*
Teacher	*Actually, what is asked from the problem?*
SR	*Finding the number of rice fields in order to get 9 tons of rice.*
Teacher	*You have the information below the problem, do you understand it?*
SR	*Yes, ma'am. Fairly understandable.*
Teacher	*Then, why don't you write it down?*
SR	*It takes a long time, ma'am.*

From the interviews, it can be seen that the subject stated that she understood enough about information on the problem. SR deliberately did not write again, because she thinks it takes a long time. Therefore, SR is enough in understanding the problem because the information should still be written to help her towards the solution.

2) Devise a plan

In devising a plan, the subject is able to explain the steps that will be done even if she does not write them. This is in accordance with the results of the following interviews,

Teacher	*Well, you've got it from the problem, then, What are the steps to solve it?*
SD	*I equate the unit first. Then I count. Lastly, I draw a sketch.*

From the interviews, SR explained that there are 3 main steps that she did, these are equate the units, calculate, and draw. Therefore, at this stage the subject can be categorized well because the planned step is quite clear.

3) Carry out the plan

In carrying out the plan, the first step taken by SR is to change the unit. The results can be seen in Fig. 17 and Fig. 18;

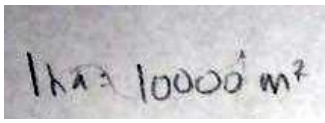

Fig. 17. The first conversion of SR.

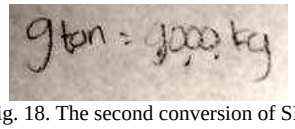

Fig. 18. The second conversion of SR.

The results are supported by interviews as follows, stating that the process was obtained from the results of memorization;

Teacher	*Okay. Now tell me the each step you do. From the First step, How do you change the unit?*
SR	*I changed the unit. But I wrote directly because it was memorized. So 1 hectare equals to 10000m^2. Then 9 tons is equal to 9000kg.*

Furthermore, the step taken by SR is to calculate, the calculation process of SR is written as seen in Fig. 19, Fig. 20, and Fig. 21;

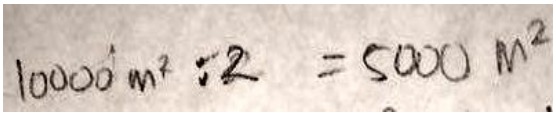

Fig. 19. The first calculation of SR.

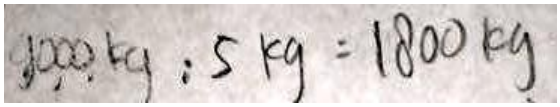

Fig. 20. The second calculation of SR.

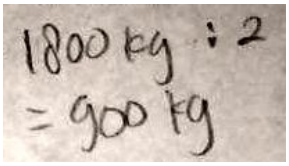

Fig. 21. The third calculation of SR.

The process, explained by SR during the interview as follows;

Teacher	*Then, after the calculation. Please Tell me, how did you do that?*
SR	*Initially I want to make the number of rice fields are 2. First, I counted 10000 divided by 2.*
Teacher	*Then? What do you get from it?*
SR	*5000 m^2 ma'am.*
Teacher	*Well, what is 5000 m^2?*
SR	*I don't know, ma'am.*
Teacher	*Okay. Then what do you do next?*
SR	*Divided 9000 by 5, ma'am.*
Teacher	*Then, where 5 it from?*
SR	*From that 5kg Ma'am.*
Teacher	*What is the next step?*
SR	*Divided by 2, ma'am. Because I want to make 2 fields.*
Teacher	*What is the result?*
SR	*900, ma'am.*
Teacher	*What is your last step?*
SR	*Draw a sketch, ma'am.*

From the interviews, the subject is able to show the calculation by determining the desired solution first, then checking the results. Furthermore, SR shows the final step by sketching the solution that has been obtained as seen in Fig. 22 below;

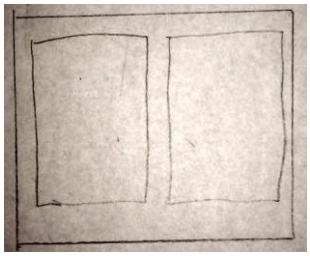

Fig. 22. The sketch of SR.

From the above, it can be seen that in carrying out the plan SR has been already in the good category because in general she is able to explain and execute important things even though there is a calculation that is not used.

4) Look back

At the stage of looking back, we can see from the results of the following interviews because in writing is not presented,

Teacher	*From your work what can be concluded?*
SR	*There are 2 rice fields that can be formed.*
Teacher	*Before, you said that you understand about the information on the problem. What is the essence of that?*
SR	*Rice fields that are shaped must be square.*
Teacher	*Then, what size of your rice fields?*
SR	*The each size is 900, ma'am.*
Teacher	*Means if the width of the rice field is 900, it is square?*
SR	*Yes, ma'am.*
Teacher	*So, how is the side?*
SR	*30 x 30, ma'am.*
Teacher	*Ok, Why don't you write another solution?*
SR	*The time is limited, ma'am.*

From the interviews, we can see that SR is able to state the conclusion. In addition, SR is also able to explain the purpose of her understanding related to the problem so that she can answer the solution correctly. But, the information on the problem is not written by her because she states there is no much time. Therefore, at this stage SR can be categorized well because she can re-explain exactly what she get, even though no other solution is presented.

At the stage of understanding the problem, basically ST, SD, and SR are able to explain the known, unknown (asked), and some important things that exist on the problem. However, the three subjects did not rewrite the information listed under the problem. ST did not write down the important information because he assumed that when it was written on the matter there was no need to rewrite it. Whereas ST should write again the information in order to facilitate it toward the solution. In line with ST, SD also did not write the information contained in the problem. Moreover SD does not read the information. SD assumes that all that has to be done is to calculate what is already in the question. In fact, the key step is in the information. Besides ST and SD, SR also shows the same thing, SR considers that by writing the information will take a long time. Therefore, SR directly does the calculation. So that at this stage ST, SD, and SR all three are categorized enough in understanding the problem.

At the devising a plan stage, the three subjects were able to explain the steps they would take when they were interviewed because in general the steps were not written down. ST only writes one step that is unit conversion. However, when interviewed, ST was able to explain the steps to be taken towards the solution. Such steps include; change unit, calculate, and sketch. Besides ST, SD is also able to explain the steps that will be done when the interview. Such steps include; changing units, doing calculations (division), and drawing sketches. In line with these two subjects, SR is also able to explain the steps to be taken towards a solution, which includes: equating units, counting, and sketching. Of the three subjects, we can see that at this stage they have an understanding that there are three main steps that must be done to arrive at the solution that is; unit conversion, counting, and sketching. Therefore, the three subjects can be categorized well, in devising a plan.

At the carrying stage of the plan, ST is able to execute all the plans that have been made appropriately so that she is able to lead to the solution. However, there is little calculation that is not used by ST, but he was able to explain that it was her fault. Unlike SD, although SD is able to explain the plan that will be done, but when she executes her plans there are few constraints. It is because when doing the calculations, SD did the same process twice. This indicates her confusion to lead to a solution. In addition, SD explained that she only determines the solution based on her wishes rather than on the information provided. This is because SD does not read the information that exists on the matter. The interesting thing is that SR is able to execute the plan that has been made exactly the same as done by ST, although there is a calculation that is not utilized by SR. So that, ST and SR can be categorized well in executing the plan, while SD can be said enough.

At the look back stage, ST does not present any conclusions or other solutions regarding the given problem. However ST was able to explain the conclusion of what she got from the results of her calculations. In addition, ST also clarified the error calculation and the wrong solution she gets. This is because there is a misunderstanding in interpreting the information on the problem. In parallel, SD did not present any conclusions or other solutions, but was able to explain the conclusions when interviewed. Furthermore, SD is more asserted on the calculations that have been done despite the reasons presented are still not quite right. This is obvious because SD does not read the information on the problem. Surprisingly, SR is not only able to explain the conclusions of the calculations performed, but also able to produce the right solution. She also explained that to lead to the solution, she utilizes the information she has understood from the problem. SR explains why she did not write another solution because time is limited. From that point, we can see that in look back stage SR can be categorized well, while ST and SD are enough.

V. Conclusion

From the result and analysis above, it can be concluded that the problem solving skills of ST and SD is almost same. The difference is only in the ability to carry out the plan, where ST is better than SD. In addition, SR actually has better problem-solving skills than ST and SD, especially at the stage of implementing the plan and looking back. Sometimes, the students who are high or medium are not always has good problem solving skills. Therefore, the teachers should be more often in training their students in working on problem-solving task (non-routine problems) in order to make their students can be more creative and critical in facing the problem.

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