

Dynamism of Open-Ended Problem Solving: Study on Junior High School Students Behavior Based on Keirsey Personality Type

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Abstract—Problem solving becomes one of several competencies which forms the heart of the mathematics literate. Reviewing the process, it cannot only be explained linearly. There is a great chance that steps will be taken again. This study addresses the dynamism of open-ended problem solving shown by junior high school students with different personality types, namely guardian, artisan, rational, and idealist. The grade 7^B, which consists of 31 students, was purposively selected from eight classes of SMPN 5 Sidoarjo. All students had to answer Keirsey personality questionnaires, mathematics ability and open-ended problem tests. There were 15 guardians, 9 artisans, 3 rationals, 2 idealists, and 2 students were not included in any type. Four students with high mathematics ability and represented each type of Keirsey personalities were volunteer interviewed based on their answers of open-ended problem test. Data were analyzed based on the steps of Krulik and Rudnick problem solving, namely *read and think*, *explore and plan*, *select a strategy*, *find an answer*, and *reflect and extend*. When solving open-ended problem, guardian, artisan, and idealist students commonly repeated the previously steps taken. This condition demonstrates dynamism in problem solving. On the contrary, the rational student showed a linear process because they did not repeat the chosen steps. This results motivate teachers to familiarize some extensively exercising on problem solving skills by considering to personality differences of students.

Keywords—*problem solving; open-ended problem; Keirsey personality type.*

I. INTRODUCTION

As an attempt to find a way out of unknown conditions by utilizing the knowledge and skills possessed [1, 2], problem solving becomes one of the main competencies of mathematical literacy [3]. It consists of five stages, namely *read and think*, *explore and plan*, *select a strategy*, *find an answer*, and *reflect and extend* [1]. According to [1, 4], problem solving steps are shown by a more complex than just a linear framework because students are likely to return to the steps that have been done previously. So that, this research will identify the dynamism of the problem solving process shown by students.

The following indicators were implemented to investigate the problem solving propose by students, as shown on Table 1.

TABLE I. INDICATORS OF PROBLEM SOLVING STEPS

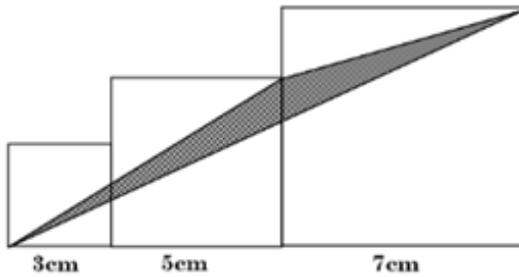
Problem Solving Step	Indicator
Read and think	- Identify what is known and what is being asked.
Explore and plan	- Make a diagram or model. - Sketch pictures, tables, or graphs.
Select a strategy	- Choose a strategy by looking at patterns, guessing, or changing problem to be simpler one.
Find an answer	- Implement strategies by using algebraic or geometric skills and calculating skills.
Reflect and extend	- Checking the suitability between the answer to what is known and what is being asked. - Find alternative ways or answers.

In general, problem is divided into closed-ended and open-ended problems. Open-ended problem has more than one way of accomplishment or correct answers [5, 6]. In this study, open-ended problem are involved due to the structure incompleteness and the number of answers and ways to settle. So that, students are expected to be more challenged to solve it. Meanwhile, because problem solving is closely related to make decision and action, a keirsey personality review is chosen to identify the characteristics of problem solving done by students with different personality types.

II. METHOD

To explore the dynamism of open-ended problem solving shown by students with different personality type, a qualitative approach is applied on this study. From eight classes of SMPN 5 Sidoarjo, the grade 7^B was purposively selected. Thirty one students of the grade 7^B completed Keirsey personality type questionnaire, the mathematics ability test, and the open-ended problem solving test. The result shows, there were 15 guardian students (5 high, 8 medium, and 2 low mathematics ability), 9 artisan students (2 high, 5 medium, and 2 low mathematics ability), 3 rational students (1 high and 2 medium mathematics ability), 2 idealist students (1 high and 1 medium mathematics ability), and 2 students were not included in any type (1 medium and 1 low mathematics ability). As volunteers, one student with a high mathematical ability in each personality type to be interviewed based on their performance on open-ended problem solving test. The collected data and the triangulation were analyzed through five problem solving steps: *read and think*, *explore and plan*, *select a strategy*, *find an answer*, and *reflect and extend*.

Open-ended problem solving test given to students as follows.



1. Determine the area of the shaded plane!
2. Determine the other way to determine the area of the shaded plane!

III. RESULTS AND DISCUSSION

A. Guardian Student (GS)

The sequence of problem solving steps shown by GS.

1) Read and think

This step was shown by identifying the known information and what is asked. Nevertheless, GS did not mention in full the information provided. He only stated, the given information was the sides lengths of the square. Even though, there are three squares, which each side already known. This condition shows that GS more focused on what can be seen clearly. It's possible, this condition is due to GS having a high sensing nature. A sensing student tends to perceive observable facts through their five senses and see things by relying on their sense [7, 8]. Regarding the matter asked, GS mentioned precisely, the area of the shaded triangle.

TABLE II. INTERVIEW EXCERPT WITH GS

R	After getting this problem, what did you think?
GS	There are squares with a side length
R	Then?
GS	I was asked to determine the area of the shaded triangle.

R: Researcher

GS: Guardian student

2) Explore and plan

After understanding the problem, GS tried to record information in his memory that the shape of the shaded area is a triangle. This condition indicates the second steps is explore and plan.

3) Select a strategy

To solve the problem, GS chose the formula of arbitrary triangle area formula. The formula would be used to determine the area of the shaded area. However, in practice GS forgot the formula so he decided not to use it. Fig 1 shows step GS in considering the formula of arbitrary triangle area.

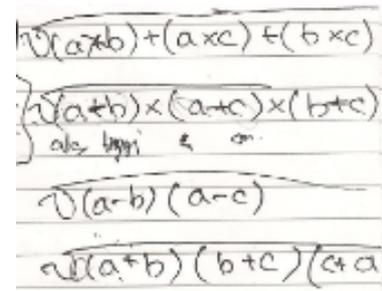


Fig. 1. Selecting strategy by GS

4) Explore and plan

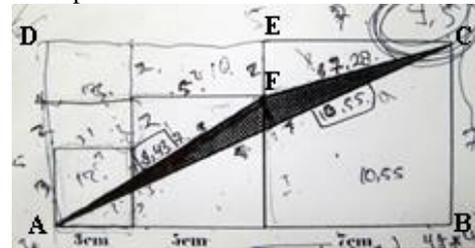


Fig. 2. Explore and plan by GS

This step was shown by making lines (Fig 2). In addition, GS wrote the sides length of the plane formed.

5) Select a strategy

After sketching help-line, he claimed that the area of the shaded area can be determined by finding the area of the rectangle ABCD first. Then, the results were subtracted by the area of triangle ABC, CEF, and the trapezoidal EFAD.

6) Find an answer

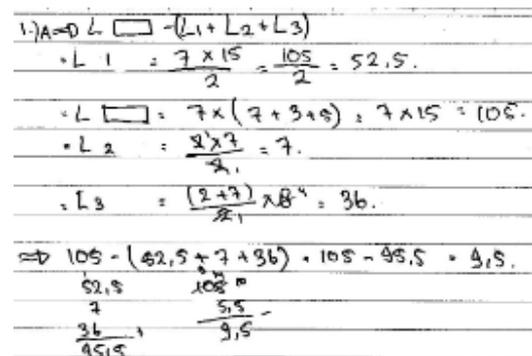


Fig. 3. GS's Problem solving performance

After setting the strategy, he start doing calculation. He got the area of rectangle ABCD, triangle ABC, triangle CEF, and trapezoidal EFAD were 105 cm^2 , $52,5 \text{ cm}^2$, 7 cm^2 , and 36 cm^2 , respectively. Then, the shaded area is $9,5 \text{ cm}^2$. In performing calculations, he implemented a strategy that had been previously chosen. According to [8], guardian person which has judging nature tends to do work in a planned and organized manner.

7) Reflect and extend

The last step taken by GS was reflect and extend, shown by examining answers and finding alternative ways. He was convinced of the truth of the answer, so he continued to read problem 2. GS understood that he was asked to look for other ways to determine the area of the shaded plane. The alternative way is the formula of arbitrary triangle area. However, GS cannot do calculation because he forgot the formula.

The sequence of steps can be described in the following framework.

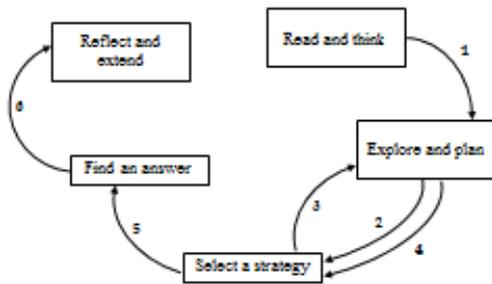


Fig. 4. Problem solving steps by GS

B. Artisan Student (AS)

The sequence of problem solving steps shown by AS.

- 1) Read and think
This step was shown by reading the problem and observing the image repeatedly in order to understand the purpose of the problem. He could identify the information provided and the question, then explained it using his own sentence even though overall it was less precise. He explained there was a square. It's area, side length, and height were already known. Actually, there were three squares which were only known their one-side length, arranged according to the picture. Meanwhile, regarding the question, he mentioned precisely, the area of shaded plane.
- 2) Explore and plan
After trying to understand the problem, AS believed that the information provided was sufficient to find the area of the shaded plane. The shaded plane is triangular, each side is one side of the other three right triangles. This condition shows that AS took explore and plan steps.
- 3) Select a strategy
This step was shown by choosing the formula of arbitrary triangle area. He explained, to determine the area of the shaded plane, he have to determine the length of each side of the shaded triangle first, using the Pythagoras formula.
- 4) Find an answer

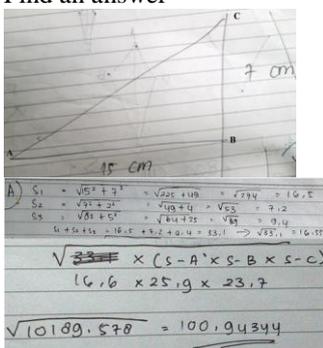


Fig. 5. Find an answer by AS

This step shown by doing calculation. He got the length of the first, second, and third side were **16,5 cm**, **7,2 cm**, and **9,4 cm**, sequentially. Based on the calculations, AS obtained the shaded area was **100,94344 cm²**. However, the answers was not the

correct one because he used the formula incorrectly. On this step, AS did not pay attention to the strategies that have been previously chosen. So that there is an inappropriate process. According to [8], an artisan has perceiving trait who tends to decide something spontaneously at that time.

- 5) Reflect and extend
On this step, AS realized there was an inaccuracy in using the formula.

TABLE III. INTERVIEW EXCERPT WITH AS

R	After finding the answer, what did you do?
AS	re-check, but not sure. Thought the formula, confused with the variable S
R	Then, finally?
AS	I knew my mistake. I changed the formula.
R	So, what is the formula?
AS	$\sqrt{S(S-a)(S-b)(S-c)}$

R: Researcher
AS: Artisan student

- 6) Find an answer
This step was shown by re-calculating the area of the shaded plane. Although the formula used was correct, he did not understand the variables in the formula. According to him, S on $\sqrt{S(S-a)(S-b)(S-c)}$ was the root of the sum of the three sides lengths of triangle. Based on the calculations, the area of the shaded plane was **7,43777143 cm²**.

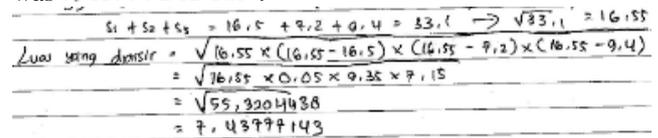


Fig. 6. Re-find an answer by AS

- 7) Reflect and extend

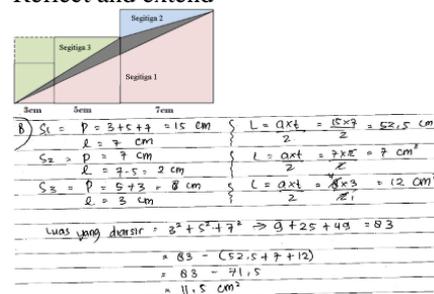


Fig. 7. Reflect and extend by AS

The final step was shown by examining answers and finding alternative ways to solve the problem. He explained, the given image can be changed to be fig 7. So, the area of the shaded plane can be determined by calculating the overall area, then subtracted by the area of the three triangles surrounding the shaded plane. He obtained the shaded area was **11,5 cm²**. However, he did not calculate the overall plane area, but only the area of three squares with a length of 3 cm, 5 cm and 7 cm. In addition, he made a mistake in determining the length of the third triangle base.

The sequence of steps can be described in the following framework.

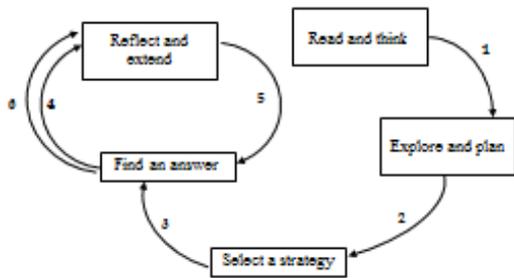


Fig. 8. Problem solving steps by AS

C. Rational Student (RS)

The sequence of problem solving steps shown by RS.

1) Read and think

The first step taken by the RS was read and think. Shown by identifying information that was known and asked. Regarding the information, he could not mention it in full. He only revealed there was a difference of 2 cm for each square. This information was not written clearly on problem. According to [9], a rational student who prefers an intuitive focus on connections and relationships between facts. Meanwhile, RS could mention exactly, the question was the area of the shaded plane.

TABLE IV. INTERVIEW EXCERPT WITH RS

R	Based on your opinion, what information did you get?
RS	There is a difference 2 cm of each square side length
R	Then, what were you told to do?
RS	Determine the area of shaded plane

R: Researcher

RS: Rational student

2) Explore and plan

This step shown by making auxiliary lines into three parts. He also wrote the sides length of the planes as follows.

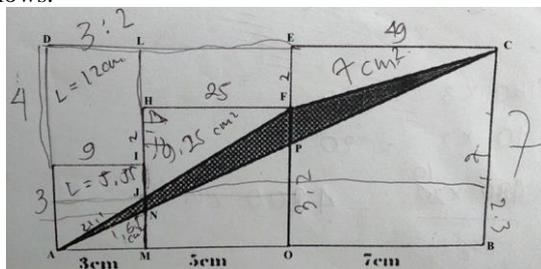


Fig. 9. Explore and plan by RS

3) Select a strategy

After making auxiliary lines, he divided the given image into three parts, consisting of rectangle AMLD and MOEL, and the square OBCE. According to him, the shaded area could be determined by adding the area of the first, the second, and the third shaded planes. The area of the first shaded plane could be determined by subtracting the area of square AMLD with the area of trapezoidal LJAD and the triangle AMN. The area of the second shaded plane could be determined by subtracting the area of rectangle MOEL with the area of trapezoid

EFJL and MNPO. Whereas, the area of the third shaded plane could be determined by subtracting the area of the square OBCE with the area of the trapezoidal OPCB and triangle EFC. This strategy was carried out by RS by paying attention to the information provided, because rational student with thinking and intuitive trait tends to start with a view of broad concepts, seeing patterns, and connections [8].

4) Find an answer

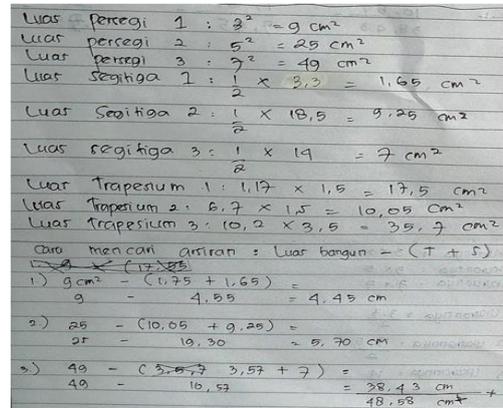


Fig. 10. Find an answer by RS

This step was indicated by doing calculation to get the area of shaded plane. However, RS tended to use estimation in determining the size of the planes. So that the results were not correct. Based on his calculations, the area of shaded plane was $48,58 \text{ cm}^2$.

The sequence of steps can be described in the following framework.

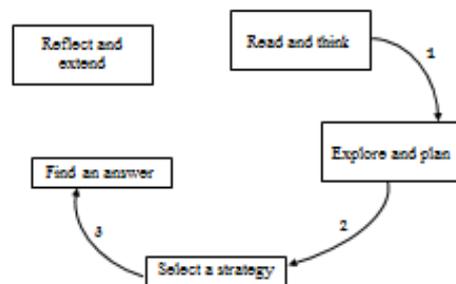


Fig. 11. Problem solving steps by RS

D. Idealis Student

The sequence of problem solving steps shown by IS.

1) Read and think

The first step taken by IS was read and think, shown by identifying information that is known and asked. He explained there were three squares whose size was known, while the question was the area of the shaded plane.

2) Select a strategy

After understanding the problem, IS chose a strategy. According to him, the area of the shaded plane can be determined by adding up the area of three squares which the sides lengths already known. Then, it had to subtracted by the area of the triangle under the shaded plane and the area of the plane that was above the shaded plane. However, IS had difficulty in determining one side of the triangle, so he decided to look for another strategy. He chose the formula of arbitrary triangle area. However,

he did not succeed in calculating because he forgot the formula.

3) Explore and plan

Because still had problems, IS returned to the steps of explore and plan, shown by making help-lines as follow.

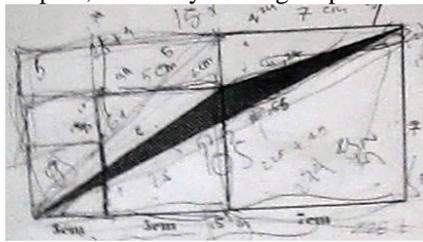


Fig. 12. Explore and plan by IS

4) Select a strategy

The new strategy taken by IS, the area of the shaded plane determined by calculating the area of the big rectangle first. Then, the result had to deducted by the area of two triangles trapezoidal which are which surrounded the shaded plane. IS explained the reason for choosing this method. He thought it was easier to implement. According to [7, 8], an idealist person with feeling nature tends to process information obtained structurally to make subjective decisions.

TABLE V. INTERVIEW EXCERPT WITH IS

R	why did you choose this method?
IS	because it's easier.
R	is there another reason?
IS	just easier.

R: Researcher
IS: Idealist student

5) Find an answer

This step was indicated by doing calculation so that he got the area of the shaded plane $9,5 \text{ cm}^2$, which is the right answer. The calculation is shown below.

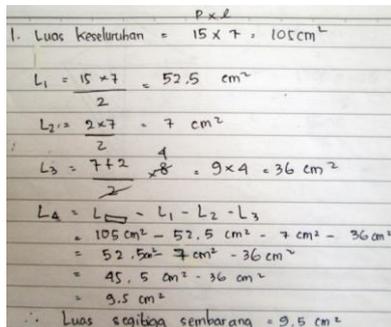


Fig. 13. Find an answer by IS

6) Reflect and extend

The final step taken by IS was reflect and extend. Shown by checking the obtained answer. However, he did not try to find alternative ways that could be used to determine the area of the shaded plane.

The sequence of steps can be described in the following framework.

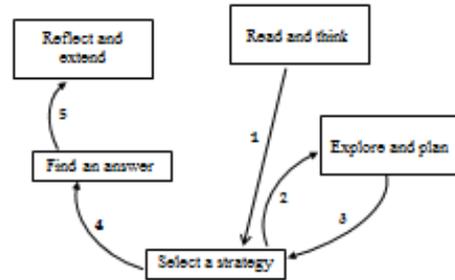


Fig. 14. Problem solving steps by IS

IV. CONCLUSION

Guardian, artisan, and idealist students do all problem solving steps. But not for rational students. It does not do reflect and extend steps. In addition, when other students show dynamic problem solving performance by repeating several steps that have been done, rational students do not do it. In solving problems, guardian students take steps to read and think, explore and plan, select a strategy, and find an answer as the last step. The problem solving dynamics shown by students can be used as guidelines for teachers to overcome students' difficulties in solving problems and designing learning that facilitates students to successfully solve them.

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