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Student's Strategic Competence toward Open-Ended Problems Before and After the Transition to Junior High School

I Sabilah[1,*], T Y E Siswono[2], and Masriyah[2]

[1]Postgradute Programme in Mathematics Education, Universitas Negeri Surabaya, Ketintang, Surabaya 60231, Indonesia
[2]Departement of Mathematics, Universitas Negeri Surabaya, Ketintang, Surabaya 60231, Indonesia

[*]Corresponding Author's email : imamasabilah16070785050@mhs.unesa.ac.id

Abstract. Strategic competence refers to mental activities that apply strategies to formulate, to represent, and to solve mathematical problems. The aim of this qualitative research is to explore strategic competence of the sixth, seventh, and eighth grade students in solving open-ended problems. There were 25 students with different mathematical competencies involved to take part in this research. Among them, three selected students with higher mathematical competency represented each grade. This research used interview-based task to explore students' strategic competence. Results showed that students understood the problems by reading and drawing/graphing them, formulated problem solving by recalling their prior knowledge about quadrilateral topic, and conveyed numerical and visual strategy to solve the open-ended problems. At last, they could determine effective solutions using arithmetical method, find all solutions correctly, and choose the cheaper ones. As an implication, we suggest further research to explore students' strategic competence with other types of mathematical competences.

1. Introduction

One major purpose for students learning mathematics is to accelerate mathematical proficiency including conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition [1]. Eventhough the five strands are interrelated, students essentially need to develop and focus on strategic competence. Those with good strategic competence indirectly master the other four competences [2]. Strategic competence is a mental activity using formulating-problem strategy, representing problems mathematically, and solving as well as choosing the most effective solution for the problems [1, 3, 4]. Students must have excellent thinking skills and do mathematics creatively, productively, critically, independently, collaboratively and communicatively through appropriate scientific approach learned in education units and other sources [5]. Creative students with good communication skills will be easier to solve any problems.

Open-ended question is a problem formulated by using multiple correct answers [6]. Learning with open-ended problem also refers to implementing an open learning that presents problems with a variety of problem solving ways *(flexibility)* and the solution can be varied *(fluency)* [7]. The main purpose of the provision of open-ended problem is not to get an answer, but to emphasis on how students can arrive at an answer, which is not fixated on the answers that must be collected to the teacher [8]. Moreover, the "openness" of the problem is meant to be lost if the teacher only gives alternatives to answer the problems. Henceforth, there must be many approaches to get the answers of the given problems. There

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were three types of open-ended problems. The first is *open the process of completion* if the question has various ways of settlement. The second type is *open the result* if the question has many correct answers. The last type is *open development of the sequel* meaning that when students have completed something, then they can develop new problems by changing the terms or conditions on an already solved matter [9]. Open-ended problem is a mathematics question that has one or more answers to a various strategies of completion [10].

So far, students who do not learn the material face difficulty in solving the addressed problems [11, 12, 13]. Those who cannot alleviate such difficulty tend to solve problems by guessing strategy. On contrasts, those who know the materials tend to determine appropriate solvencies to troubleshoot the problems. These typical students then have stronger strategic competences and are able to encounter various problems [14, 15, 16].

The aim of this qualitative research is to explore strategic competence of the sixth, seventh, and eighth grade students in solving open-ended problems. Results depicted that student understood the problems by reading and drawing/graphing them. They formulate problem solving by recalling their prior knowledge about quadrilateral topic. They conveyed numerical and visual strategy to solve open-ended problems. Finally, they could determine an effective solution using arithmetical method, find all solutions correctly, and choose the cheaper ones. As an implication, we suggest further researchers to explore students' strategic competence with other types of mathematical competences.

2. Method

This qualitative study involved three of 25 students in an interview-based task. Twenty-five students were included into quadrilateral learning class and given (1) mathematical competence test to categorise students' mathematical competencies and (2) task in a form open-ended problems. The subjects selected for interview were those who met the following criteria: had studied the quadrilateral material, able to communicate their ideas clearly, and high students' mathematical competency. Interview data were analysed in three stages: data condensation, data presentation, and drawing conclusions [17]. Data condensation referred to the process of selecting, focusing, simplifying, abstracting or transforming the obtained data that appeared in the full corpus of field notes, interview transcripts, documents, and other empirical materials. Data presentation was in the form of a set of narrative text information/ data arranged orderly and systematically, which further eased to draw conclusion. Based on the data obtained through tests and interviews, researchers then made indicators for each aspect of strategic competence (see Table 1).

Table 1. Indicators of Strategic Competence.

Strategic Competence Aspects	Indicators
Formulating Problem	• Students could write and explain the given information and question. • Students could explain the relationship between the given information and question and relevant prior knowledge.
Representing Problem	• Students could represent problems using diagram/ table/ picture/ mathematics model/ equation/ numeric/ symbolic/ verbal/ graphic/ etc.
Solving Problem	• Students could write and explain a plan to solve. • Students solved problems correctly. • Students could explain problem-solving steps correctly.

3. Results and Discussion

3.1. Formulating

Students formulated the solution of the given problems to understand comprehensively where a mathematical formula could be used. Sixth grade students directly drew and estimated the area by considering her calculation, comparing prices on different size, and choosing the cheaper solutions. The seventh grade student used multiplication and division operations and got the total of all the area, calculated and compared cost reduction and operating expenses using the formula for a rectangular area, and determined the effective resolution on a more economical choice. The eighth grade student wrote down given information and answers addressed on problems with enclosed conclusion. First interview was for the sixth grade student (S1), the second interview was for the seventh grade student (S2), and the third interview was for the eighth grade student (S3), of which all used different strategy to formulate completion of financial problems in a form of open-ended problems given by researcher (R). All of them were compared the different size of the ceramics option and they chose the cheaper prices for the solution. The difference was their perspectives about systematic formula addressed to the problems.

R : Please explain the steps of completion that you will use!

S1 : First, I drew and estimated the size of ceramics. Then, I counted the price for each ceramics' size before deciding the cheaper ceramics' price, I compared the prices of the cost with different sizes.

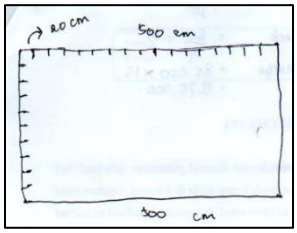


Figure 1. S1's First Step

S2 : First, I found that the key of the problems was "minimal price to buy the ceramics until the area closed"

Then, I wrote the given information and question from the problems. Finally, I solved the problem by comparing the size of the ceramics and their prices and choosing the cheaper ceramics price.

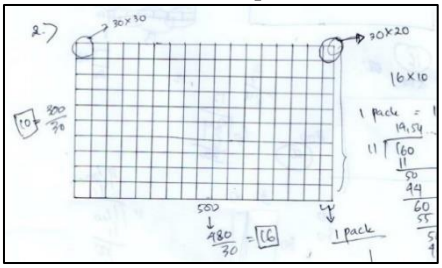


Figure 2. S2's First Step

S3 : I calculated all prices of each ceramics' size and then compared all of them with a same quantity of living room area (multiplying 3 meters and 5 meters) to show the cheaper ceramics' price.

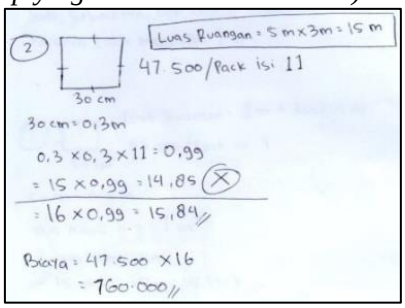


Figure 3. S3's First Step

3.2. Representing

Student's representation strategy in open-ended problems used numerical and visual strategies. The sixth and seventh grade students drew a picture to represent the given information and idea regarding the problem solving statements. Meanwhile, the eighth grade student used a simple strategy such as numerical calculations and numbers in representation.

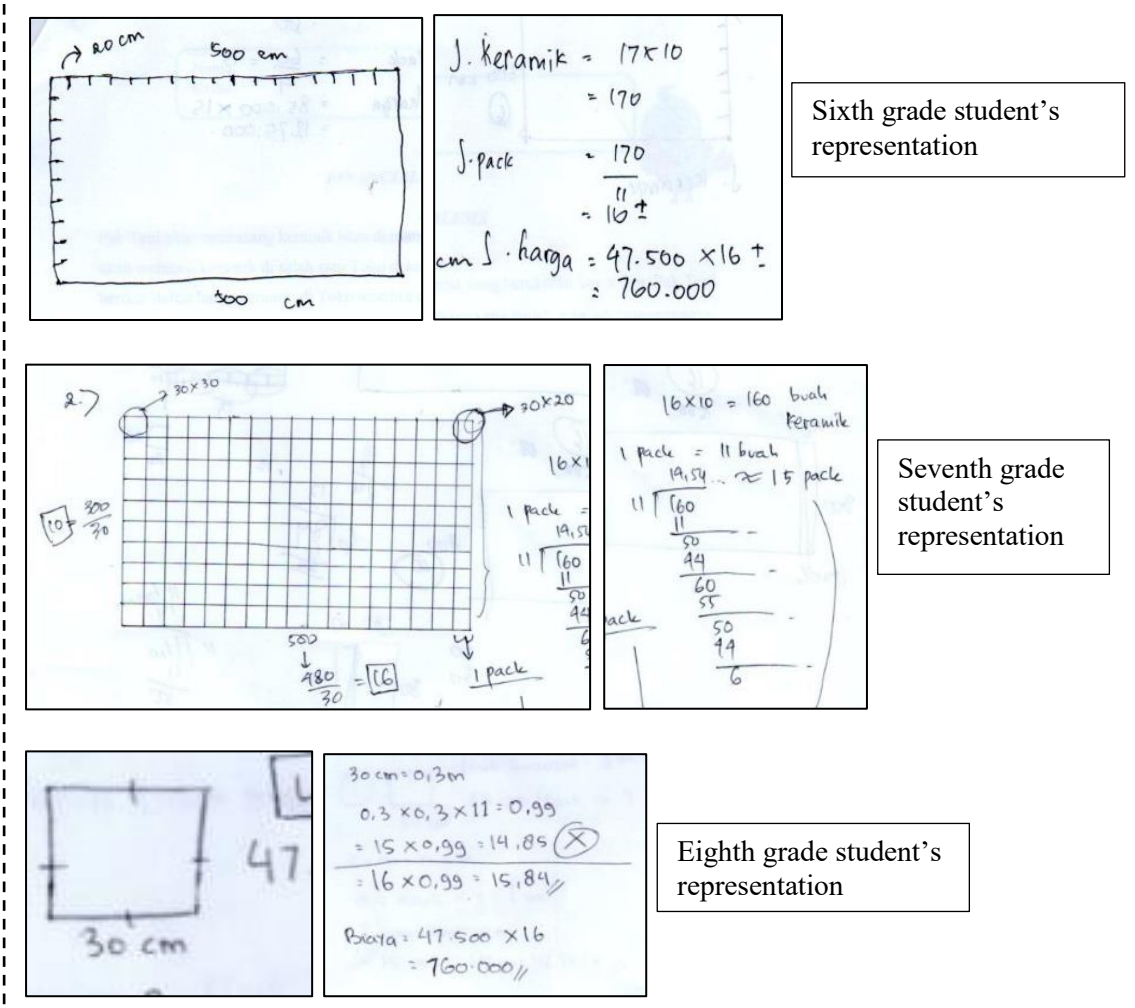


Figure 4. Students' Representations

Figure 1 shows that the sixth, seventh, and eighth grade students used numerical and visual strategies to represent problems and problem-solving ideas.

3.3. Solving

The sixth grade student directly drew and determined the cost by estimating the calculation. The seventh grade student performed various arithmetic operations such as multiplication and division and used a rectangle area formula to resolve the cost. The eighth grade student chose to use a sequence of completion by writing down the information about the problems and then conducted the calculations including drawing the conclusion for each ceramics' size.

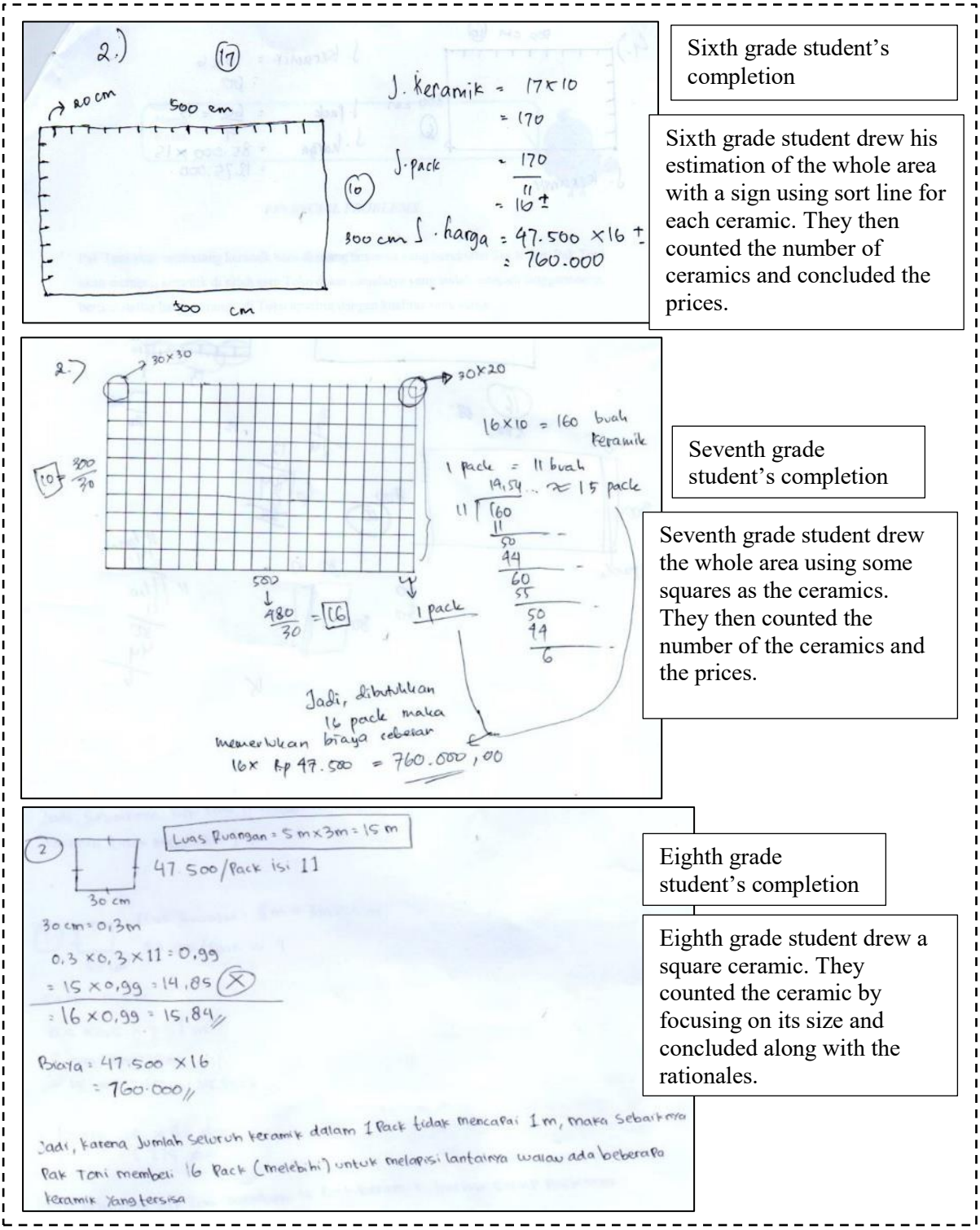


Figure 5. Student's Answer to Solving Open-ended Problems

Figure 2 showed that the sixth, seventh, and eighth grade students determined the effective solution using arithmetic calculation and choose the cheapest solution.

That is, students who did not learn the materials found difficulty in solving the problems [11, 12, 13]. Consequently, they used guessing strategy to answer or solve the problems. However, those who got the basic materials might have high strategic competences and be able to solve various problems [14,15,16].

4. Conclusion

Results showed that students understood the problems by reading and drawing/graphing them. They formulated problem solving by recalling their prior knowledge in quadrilateral topics. They solved the open-ended problems by numerical and visual strategy. Finally, they determined an effective solution using arithmetical method, found all solutions correctly, and chose the cheaper ones.

5. Implication

We suggest the next research to explore students' strategic competence with other types of mathematical competences.

6. Appendices

The following is the open-ended problems used in this research constructed by the researchers

Mr. Toni will set new ceramics in his living room measuring 5m × 3m. Mr. Toni will buy a ceramic in one of the shops near his house. The ceramic price list at the store of the same quality is shown below.

Ceramics Size	Prices	Contents /pack
20 × 20	44.500,00 IDR/pack	25 pcs
30 × 30	47.500,00 IDR/pack	11 pcs
40 × 40	76.000,00 IDR/pack	6 pcs
50 × 50	85.000,00 IDR/pack	4 pcs

Please help Mr. Toni to count minimal cost to buy the ceramics until the area closed. Write and explain your answer and this reason.

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