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Students' ability in solving open-ended mathematical problem with the context of Songket motif

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Abstract
The aims of this research was to analyze student's ability in solving open-ended mathematical problem, using Songket motif context, particularly *Kembang Tengah* motif. The subjects were 24 seventh graders of SMPN 9 Palembang. The results show that in solving problem ability, 88.33% of students understand the problem, 59.72% of students were able to construct and 72.22% applied the plan, while 52.78% wrote final conclusion. No students evaluate their solution towards the problem. It is found that in implementing open-ended problem with traditional context, students have different solution based on their various experience towards the context, problem solving schema, and mean-putting on the problem. They also applied multiple problem solving strategies in working the problem. The similarity was the use of assumption in solving the problem. However, some assumptions were inconsistent with their prior work nor other mathematical concepts. Therefore, it is important for teachers and researchers to focus on emphasizing students' written self-evaluation in order to check and improve their solution. Another suggestion is to see the metacognitive process in solving open-ended mathematical problem using certain tradition. Furthermore, teachers should engaged more in using open-ended problems and scaffold students when they are facing obstacles in solving them.

Keywords: PISA; mathematical problem; problem solving; development research; songket

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Introduction

Mathematics is a universal science that underlies the development of modern technology, has an important role in various disciplines and advances human thought power (Maass, Geiger, Ariza, & Goos, 2019; Sun, 2018; Ibrahim & Suparni, 2009). In learning mathematics, there are several abilities students must have, one of which is the ability to solve problems (Siagian, Saragih, & Sinaga, 2019; Annizar, Maulyda, & Gusti Firda Khairunnisa, 2020). In addition, the ability to solve problems is the goal of learning mathematics (Anggraena, 2019; NCTM, 2000). Having good problem solving skill is very important for students. This is not only useful for their school lives, but also in their daily lives (Porgow, 2005; Saragih & Napitupulu, 2015). Mathematical problem solving activity allows students to connect various abstract concepts and making sense to real-world problem (Lester & Cai, 2016; Stohlmann & Albarracín, 2016). Solving mathematical problems also benefit students to enhance their thinking abilities, such as reasoning, critical, creative, even metacognitive thinking (Amir, Hasanah, & Musthofa, 2018; Basri, Purwanto, As'ari, & Sisworo, 2019; Maskur, et al., 2020; Pratama, Lestari, & Jailani, 2018). More importantly, being able to solve mathematical problem can improve students' confidence and motivation in learning mathematics and think mathematically (Hendriana, Johanto, & Sumarmo, 2018; Peranginangin, Saragih, & Siagian, 2019). Hence, problem solving is an integral part in learning mathematics, so that it should not be separated from mathematics learning.

In Indonesia, students have poor problem-solving skills compared to other countries (Tanudjaya & Doorman, 2020; OECD, 2019). Based on the Program for International Student Assessment (PISA) ranking in 2018, Indonesia ranks 75 out of 80 countries (OECD, 2019). This also means that the ability of Indonesian students to solve problems that demand the ability to examine, give reasons, communicate effectively, solve problems and interpret problems in various situations is still very weak (Hewi & Shaleh, 2020; Tanudjaya & Doorman, 2020). Findings from some studies suggest that students experienced difficulties in answering test questions that measured analytical ability, problem solving, and interpretation of mathematical questions (Hadi, Retnawati, Munadi, Apino, & Wulandari, 2018; Tambychik & Meerah, 2010; Rudi, Suryadi, & Rosjanuardi, 2020). Many factors could cause this phenomenon. One contributing factor is that teachers rarely implement problem solving activities (Tanujaya, Mumu, & Margono, 2017; McCormick, 2022; Russo, et al., 2020). Often times, mathematics tasks in classroom solely demand lower thinking ability to solve them (Boesen, et al., 2014; Hiebert, 2003; Lithner, 2004). Furthermore, many textbooks in school don't provide opportunity for student to generate mathematical ideas and the exercises tend to support procedural skill rather than solving challenging problem (Putri, 2017; Walle, Karp, & Williams, 2010; Jäder, Lithner, & Sidenvall, 2020). On the other hand, students also rarely practice to solve high-level questions on their own (Nur Alfiani Hafidzah, 2021; Nasution & Pasaribu, 2021).

One way to help students improve their problem solving skills is to implement problem solving based instruction, where the main treatment is to give students higher order thinking skills (HOTS) mathematical problems (Mustapha, Rosli, & Saleh, 2019; Hasyim & Andreina, 2019). One form of these HOTS problems is the open-ended problem (Ulinnuha, BudiWaluya, & Rochmad, 2021; Hamimah, Kenedi, & Zuryanty, 2020). Open problems can be grouped into three types: (1) the process is open, (2) the results are open, and (3) the way of further development is open (Becker & Shimada, 1997). By applying open-ended problems at school, students will get used to thinking creatively and critically (Damayanti & Sumardi, 2018; Yee, 2000; Sapta, Pakpahan, & Sirait, 2019). The nature of open-ended problems is that by solving them, students are invited to achieve extended ideas and challenge their wider perpectice and understanding (Swenson, Beranger, & Johnson, 2021; Lock, 1990). They allow students recognize their own capability and work on their own speed (Olewnik, Yerrick, Simmons, Lee, & Stuhlmiller, 2020). The focus is not restricted to a certain solution. Students with different ability will be able to experience both challenges and successes on the same problem. Furthermore, when students are able to bring various solutions, there will be potential to discover something new (Lehman & Stanley, 2008; Becker & Shimada, 1997).

Many researches focused on developing open-ended mathematical problems (Surya, Zulfah, Astuti, Marta, & Wijaya, 2020; Kurniawan, Putri, & Hartono, 2018; Putri, 2017). However, formulation of the problems developed in these researches tends to be abstract or not in natural setting. Hence, it is less meaningful for students, especially junior high school students. Therefore, in this study, an open-ended problem based on local culture will be developed, which uses the context of the Palembang *Songket* motif. The use of cultural contexts that are close to students in learning mathematics has several benefits, including: help students understand the phenomenon of mathematics from the perspective of their own life experiences (Charmila, Zulkardi, & Darmawijoyo, 2016), reduce the abstract nature of learning mathematics (Francois, 2012), and create positive perception on mathematics (Araiku, Somakim, & Pratiwi, 2020).

From the description above, researchers conduct research with the title "Students' ability in solving open-ended mathematical problem with the context of Songket motif". This study aims to describe students' problem solving ability towards open-ended mathematical problem with the employment of Songket motif as the problem's context.

Methods

This research is a descriptive research that aims to analyze students' ability to solve open-ended problem with the use of *Songket* context. The subjects of this research were 24 students of class VII of SMPN 9 Palembang, South Sumatra. The instruments and the data source in this research are shown in Table 1.

Table 1. Data instrument and data source

Instrument	Data	Data Source
Validation sheets: Open-ended problem and Interview sheet	Validation score	Validators
Open-ended problem	Students solution	Students
Interview sheet	Interview transcript	Students

Validity Criteria

The validity process meant to ensure if the instruments contained all the essentials that the researchers need to obtain the desired data and excluded all the unnecessary items (Yusoff, 2019). There were 3 validators in this research, 2 lecturers that are expert in problem solving and realistic mathematics, and one junior school mathematics teacher. The validity tests in this research were held for the open-ended problem and interview sheet. The open-ended problem criteria were content, construct, and language validity (Araiku, Parta, & Rahardjo, 2015). The interview sheet validity consisted of content and language (Araiku, Parta, & Rahardjo, 2015).

The validity tests were analyzed quantitatively and qualitatively. The quantitative analysis was done by calculate the percentage of the total score from the validators by the maximum score. The validity criteria can be seen in Table 2. The qualitative analysis meant the researches consider the validators' suggestions regarding the instruments (Taherdoost, 2016). In this condition, the instruments were revised based on the validator's suggestion so that the instruments have good quality. The validation data for the instrument was also being tested for the reliability of the validation sheet (Plomp, 2010). Reliability testing is done by calculating the difference in score for each statement from the validator. Evaluation on the *i*-th statement is categories as agreed if the average difference of validator assessment is not more than 1 (Araiku, Parta, & Rahardjo, 2015). In other conditions, it is stated as disagree. Furthermore, if the percentage agreed for all statements is not less than 80%, then the validation sheet is declared reliable.

Table 2. Validity Criteria

Percentage	Criteria
$85\% \leq SP \leq 100\%$	Very valid
$50\% \leq SP < 85\%$	Valid
$SP < 50\%$	Invalid

Problem Solving Assessment

The researchers conducted desk evaluations to see students' problem solving abilities based on problem solving indicators which synthesized from Polya's problem solving phase (Polya, 1973), Hong's ill-structured problem solving process (Hong & Kim, 2016) and Araiku's problem solving indicators (Araiku, Parta, & Rahardjo, 2015), which focused on 5 abilities, namely understanding the problem, constructing plan, applying, concluding, and evaluating. The evaluating indicator is implemented due to the nature of open-ended mathematical problem is open solution, hence it is important for students to be able to justify their solutions (Douglas, Koro-Ljungberg, McNeill, Malcolm, & Therriault, 2012) . The indicators, sub-indicators, and the maximum score for each indicator is presented in Table 3.

The procedure to calculate students' grade is as follow:

1. Sum up all students' score in each indicator.
2. Calculate the percentage of the total score in each indicator.
3. Make conclusions about student response data. The conclusions are referred to Table 4.

Table 3. Open-ended Problem Solving Indicator

Problem Solving Indicators	Sub-Indicators	Maximum score
Understanding the problem	Interpret information from verbal, nonverbal statements, pictures, or graphics	3
	Identify or formulate questions	2
Constructing plan	Make a consistent problem-solving plan	3
Applying	Applying a problem-solving plan	3
	Applying mathematical concepts	3
Concluding	Provide problem solutions	3
Evaluating	Evaluate the given solution	3

Table 4. Open-ended Problem Solving Score Criteria

Percentage	Criteria
$85\% < TS \leq 100\%$	Excellent
$70\% < TS \leq 85\%$	Good
$50 \leq TS \leq 70\%$	Fair
$TS < 50$	Poor

The works from the students then cross-examined by conducting interview to some subjects that represent most likely solution as representation of the subjects.

Results

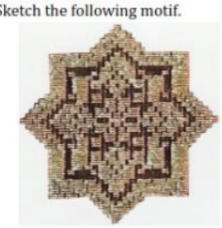
Researchers develop open-ended mathematical problem and interview sheet. Then these instruments validated by three experts. The aspects that was observed for open-ended problem consisted of constructs (clarity on the formulation of instructions, indicators, and adjustable with work time), content (consistency of the questions to the determined basic competencies and indicators, to measure students' ability to determines the area of Songket motif, and in exploring students' problem solving ability), and language (good and correct use of Indonesian, not to cause double interpretation, and easily understood by students). Two criteria were evaluated by the validators on the interview sheets, which are content (consistent to check students understanding, developed consistently with problem solving steps, the questions are open-ended and hence semi-structured) and language (correct use of Indonesian, in accordance with the child's development, not ambiguous).

Based on the validation results on open-ended problem above, the percentage of total scores is calculated as follows:

$$SP = \frac{101}{120} \times 100\% = 84.17\%$$

According to the established validity criteria, a critical thinking ability test can be said to be valid. Furthermore, the average difference for all statements is less than 1, meaning that all statements are agreed in accordance with established criteria. The percentage of agree is 100% so it can be concluded that the validation sheet of the open-ended problem is reliable. Some suggestion from validators can be seen in Table 5.

Table 5. Comment and Revision on Open-ended problem

Before Revision	After Revision
Validator's comment: Pointing the desired motif with blue square is not enough. The pattern is unclear. It's better to add additional picture so that students can sketch the motif in question before guessing the size.	
Songket is a traditional fabric from Palembang, Sumatera Selatan. It is known for its luxury, elegance, and elaborate design. The fabric is a combination of silk and golden yarn. A fabric usually comes with a size of 180 cm x 90 cm. Songket consisted of 7 motifs – *Kembang tengah, ombak, umpak bongkot, tawur, pengapit, umpak ujung,* and *tretes. Kembang tengah* motif is the main motif which placed at the centre of fabric which usually have the area of 120 cm x 50 cm. One of the motifs in *Kembang tengah* is jasmine flower, a 16-regular-sided star. 	a. Sketch the following motif. 
Validator's comment: Switch use of the words "Determine" and "Approximate" for questions "a" and "b", because the estimation technique of students is in determining the size of the motif. Write explicitly the *Kembang Tengah* motif so that students can focus on determining the solution to the problem.	
a. Determine its measurements and explain how you get them. b. Approximate the area of the flower motif.	b. Approximate each *Kembang tengah* motif measurements and explain how you get them. c. Determine the area of the *Kembang tengah* motif based on your measurements.

Based on the validation results on interview sheet above, the percentage of total scores is calculated as follows:

$$SR = \frac{65}{72} \times 100\% = 90.28\%$$

According to the established validity criteria, a critical thinking ability test can be said to be very valid. Furthermore, the average difference for all statements is less than 1, meaning that all statements are agreed in accordance with established criteria. The percentage of agree is 100% so it can be concluded that the validation sheet of the questionnaire is reliable.

Problem solving ability

In Table 6, it can be seen that some students failed to demonstrate excellence in solving mathematical problem. Table 6 concludes students' performance in solving the problem.

Table 6. Students problem solving performance

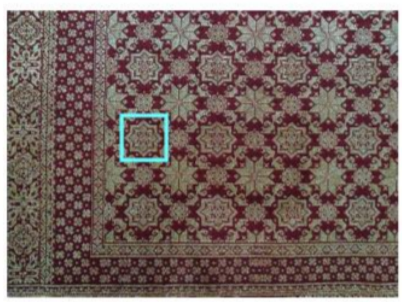
Indicators	Total Score	Maximum Score	Percentage	Criteria
understanding the problem	106	120	88.33%	Excellent
constructing plan	43	72	59.72%	Fair
applying	104	144	72.22%	Good
concluding	38	72	52.78%	Fair
evaluating	0	72	0%	Poor

Based on Table 6, it can be seen that the highest score percentage is at the stage of understanding the problem with 88.33% (excellent) and the lowest is evaluating with a percentage of 0%. This is because some students are able to solve the problem based on their assumptions, but they didn't evaluate their final solution toward any mathematics concepts. This of course has the potential to cause errors in providing problem solutions because there is no evaluation process to see the consistency of the process both internally and externally (Andrade & Valtcheva, 2009; Andrade & Du, 2007). In addition, it can be seen that the percentage of the applying stage (72.22%) is higher than the constructing plan stage (59.72%). This is because the students simply didn't write a plan, but has one in mind. This is in line with the opinion that in the problem-solving process, students tend not to write down the steps of understanding and making a problem-solving plan, but go straight to the application stage (Saputri & Mampouw, 2018; Yuwono, Supanggih, & Ferdiani, 2018). The same thing happens in writing conclusions. Many students do not write down the final conclusion after completing the calculations.

Discussion

There are 5 problem solving indicators used in this research, understanding the problem, constructing plan, applying (carrying out the plan), concluding, and evaluating. As the result already gave overall picture of how students performed based on these indicators, in this section, we're going to discuss the works of some students. There were 2 students, AO and SP, who are recruited as correspondences in this research. These subjects were chosen because their performances were representative enough for the rest of the class. The problem handed to the students is shown in Figure 2.

Songket is a traditional fabric from Palembang, Sumatera Selatan. It is known for its luxury, elegance, and elaborate design. The fabric is a combination of silk and golden yarn. A fabric usually comes with a size of 180 cm x 90 cm. Songket consisted of 7 motifs – *Kembang tengah, ombak, umpak bongkot, tawur, pengapit, umpak ujung,* and *tretes*. *Kembang tengah* motif is the main motif which placed at the centre of fabric which usually have the area of 120 cm x 50 cm. One of the motifs in *Kembang tengah* is jasmine flower, a 16-regular-sided star.



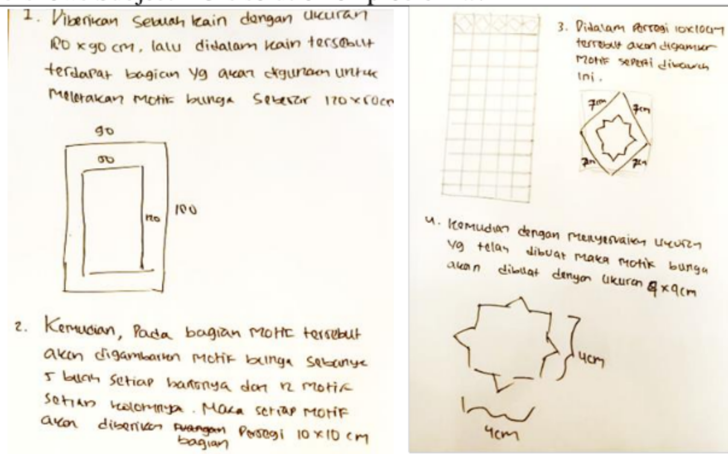
a. Sketch the following motif.

b. Approximate each *Kembang tengah* motif measurements and explain how you get them.
c. Determine the area of the *Kembang tengah* motif based on your measurements.

Figure 2. Developed Problem

Subject AO

Figure 3 shows Subject AO's solution on problem a.



Translation:

1. Given a fabric with size 180×90 cm. The inside the fabric, there is an area that will be used to put flower motive with size 120×50 cm.
2. Then, at the motive will be drawn 5 flower motive in each raw and 12 motive in each column. Then each motive will be given square part 10×10 cm.
3. Inside 10×10 cm square will be drawn the following motive.
4. Then, by adjusting the size, the motive that will be drawn will be 4×4 cm.

Figure 3. Subject AO on problem a

For the first question, subject AO gave quite clear explanation about how he derived the measurements of the motif. The first step is a reinterpretation of the initial problem. This step indicates that the AO understands the problem given, hence satisfied the first problem solving indicator. The second step is an assumption that the place for *Kembang Tengah* will only fit for 60 motifs, which the size is 5 rows × 12 columns. Therefore, each motif will occupy an area of 10 cm × 10 cm at the fabric.

R : *Let us now consider the second step. Why can AO decide that each row can only have 5 motifs and each column can only have 12 motifs?*

AO : *hmm (thinking)... I was just guessing, sir. Just use feeling, sir. The thing is, the size of the cloth in the middle is 120 cm long and 50 cm wide, so I think 12 equals 5 only.*

R : *Is there another size possible?*

AO : *You can, sir. Like 5 cm × 5 cm each motif. So the motive could be more.*

R : *Why not write that down?*

AO : *The problem is that if 5 cm × 5 cm the motif is too small, it doesn't make sense*

Based on the results of the interviews above, it can be concluded several things. First, in the open-ended problem solving process, AO students apply several problem solving strategies simultaneously. When AO explains how he determines the area of each motif is 10 cm × 10 cm, the strategy he uses is intelligent guessing and testing (approximation) (Intaros, Inprasitha, & Srisawadi, 2014). This strategy arises because AO relates the length and width of the inside of the fabric, which is 120 cm × 50 cm. Indirectly, AO is able to see the relationship between the concept of the area of the flat figure and the greatest common factor (GCF). In the process of solving mathematical problems, especially in open-ended problems, the ability to relate various concepts in mathematics is very crucial (Douglas, Koro-Ljungberg, McNeill, Malcolm, & Therriault, 2012; Bahar & Maker, 2015). In addition to intelligent guessing and testing strategies, another strategy that emerged from AO in answering question a was logical reasoning (Intaros, Inprasitha, & Srisawadi, 2014). This can be seen when AO asserts that although there are other solutions, namely the area of each motif is 10 cm × 10 cm, and this does not make sense because it is too small. This is also the basis for the second conclusion, which is the process of making sense of the results of problem solving by AO. AO is able to argue that certain sizes do not make sense to be a solution to the problem because AO is well acquainted with the Songket fabric which is his culture. This confirms several research results that learning mathematics, which is associated with students' local culture, will make it easier for students to interpret and understand mathematics (Harding, 2021; Abiam, Abonyi, Ugama, & Okafor, 2015; Nursyahidah, Saputro, & Rubowo, 2018). It will also be easier for students to understand because their abstract knowledge can be accommodated and assimilated by their knowledge in everyday life (Hasbi, Lukito, & Sulaiman, 2019). Furthermore, in this study it can be concluded that one of the advantages of using real contexts in everyday life, especially regional culture, in designing open-ended mathematical problems is that there is a good sense of students as a basis for solving mathematical problems, so that even offered can vary, but does not contradict their understanding of real life.

The area of 10 cm × 10 cm, however, is not fully filled with the particular *Kembang Tengah* motif. The subject made another assumption that the motif will only take place at the center of each area, which illustrated in statement 3. AO determined that the *Kembang Tengah* motif will be placed inside 7 cm × 7 cm square. This decision was really interesting, hence the researcher asked AO.

R : *AO can explain why this is 7 cm (while showing Figure 4)?*

AO : *Because this box has a side size of 10 cm, it will be 7 cm.*

R : *How do I get it?*

AO : *This is a square, sir, so this point (pointing point A, see Figure 4) is in the middle. If it is in the middle, it means that the size from here to here (pointing point A and point B, see Figure 4) is 5 cm. After that, use Pythagoras, sir. 5 squared plus 5 squared equals 50. So the root of 50 is close to the root of 49, so the root of 49 is 7.*

Based on the results of the interview, AO was able to integrate the concept of the Pythagorean Theorem with solving the problem. In addition, AO also provides an approximation technique as a strong reason to do rounding.

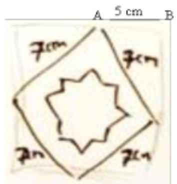


Figure 4. AO's step 3

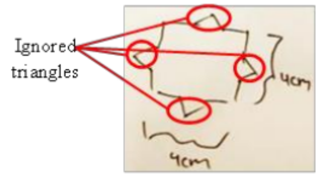


Figure 5. AO's solution mistake

After an adjustment, AO concluded that the *Kembang Tengah* motifs have the size of $4\ cm \times 4\ cm$. However, this measurement is only for the square shape which completely ignoring the triangle shape (see Figure 5). And after an interview, subject AO stated that he put $4\ cm \times 4\ cm$ as the size only because it is less than 7 cm and no mathematical reasoning behind this decision.

Hence, it can be seen that for the first question, subject AO made 3 assumptions in order to solve problem a. This result is in line with a study from Mortos, et. al. and Diefes-Dux, et. al. that stated in order to solve a mathematical problem, sometimes assumption of a situation or probability is needed (Mourtos, DeJong-Okamoto, & Rhee., 2004; Diefes-Dux, Zawojewski, & Hjalmarson, 2010).

Based on the solution of problem a, subject AO continued to solve problem b, which is determining the size of the motif (Figure 6). This answer meets inconsistency with statement 4 in solution a. Comparing both models, ΔABC must be a isosceles triangle with $AB = AC = 1\ cm$ and $BC = 2\ cm$, which is impossible to create a triangle with such measurements, because $AB + AC = BC$.

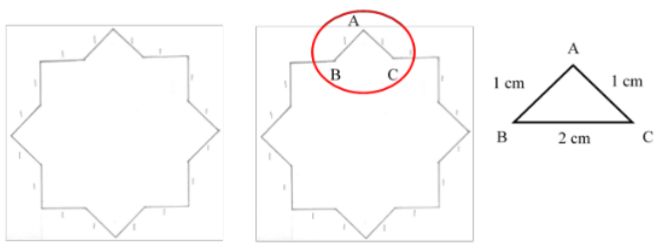


Figure 6. Subject AO on problem *b*

The error of solution b caused further mistake in solving question c, which finding the area of the motif. Subject AO solving the problem by dividing the picture into two main parts, a square and 4 congruence triangle. Subject AO didn't find any problem in determining the area of the square. However, in determining the area of a triangle, AO made some error. In Figure 7, the subject miss calculating $\sqrt{1+1} = \sqrt{1}$ as the height of the triangle, which supposed to be $\sqrt{1+1} = \sqrt{2}$. In this particular answer, the researcher conducted an interview to see how the subject arrived to such conclusion.

R : *Are there any inaccurate calculations in this section?*

AO : *Wait a minute sir, I'll take a look first (pay attention to the answer for a moment)...*

R : *Oh yes sir, something is wrong. Should be root 2.*

AO : *That means the next calculation is also wrong, sir. The area of the triangle is* $\frac{2\times\sqrt{2}}{2}=\sqrt{2}$. *So, the total area is also wrong, sir. Should be* $16+4\sqrt{2}$.

From this interview, it can be concluded that subject AO didn't consider to evaluate the work he has done. However, during interview, this evaluating process appeared verbally. AO realizes his mistakes and eventually was able to improve the solution. This highlights the importance of scaffolding in the process of solving HOTS problems, like open-ended problem (Edson, 2017; Swenson, et al., 2021). Based on this result, it also can be concluded that evaluating indicator could appear both written and verbally.

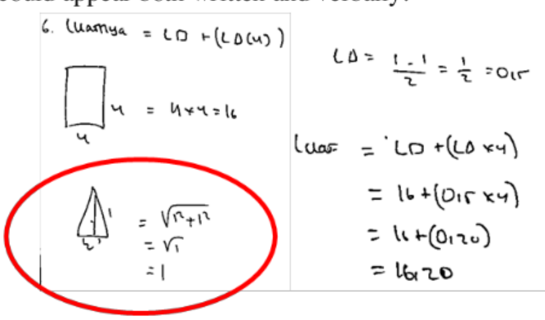


Figure 7. Subject AO on problem *c*

Subject SP

In solving problem a, subject SP put similar reasoning. The difference with subject AO was she derived on the conclusion that the space occupied for each motif is 6 cm × 6 cm, including the shape of four triangles. She used different technique to find 16-sided plane ABCDEFGHIJKLMNOP. First, she found the area of PQRS and then subtracted by exceeding area (8 equal trapezoids). This partitioning problem solving strategy was proper to solve this kind of geometric problem (Yunita, Maharani, & Sulaiman, 2019; Cordia, 2021).

Overall, there is no problem with the strategy to find the solution. However, some procedures met some unexplained decisions and causing mistakes. For instance, SP stated that $AB=\frac{1}{2}PC$ based on her assumption. And then in order to find the distance between line PC and line AB or the height of trapezoid BCP (t), there was no mathematical reason why $t=\frac{1}{2}AB$. Therefore, the researchers conducted an interview.

R : *SP, can you explain why* $AB=\frac{1}{2}PC$*?*

SP : *The thing is, this is an isosceles trapezoid, so the shape is symmetrical. It means that the hypotenuse is the same as left and right, so the right triangle is the same. So it is divided into two sir.*

R : *If, for example, we draw a line here (make a line that goes through B to the right PC) and here (make a line through A perpendicular to PC), what is the approximate height and base?*

SP : *(working in silence) Different, Sir*

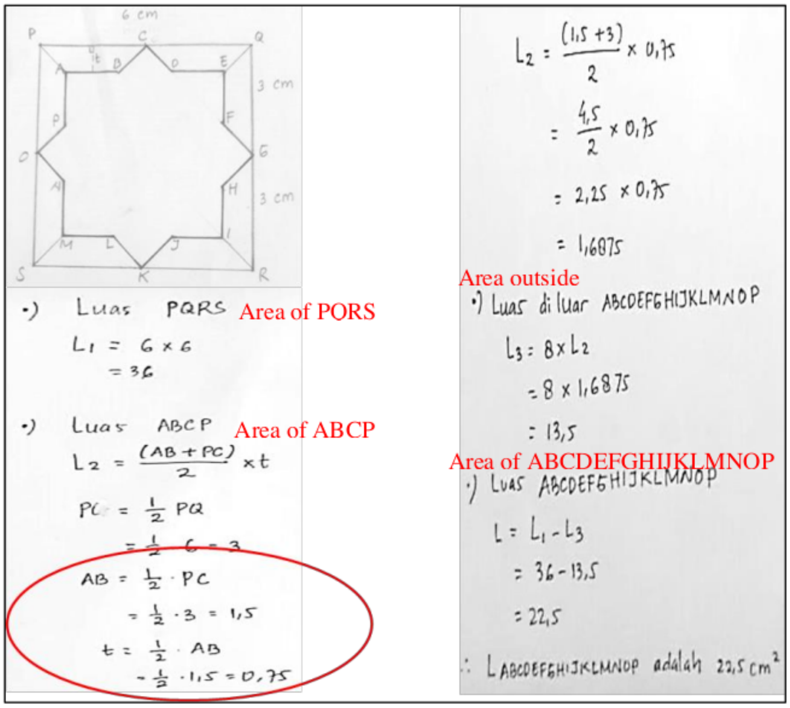


Figure 8. subject SP on problem *b* and *c*

Based on this interview, it can be seen that subject SP failed to improve her solution. It's because SP made assumptions that were not used properly. For example, based on SP's solution, if $t = 0.75\ cm$ and the distance between line EF and GQ is also $0.75\ cm$, then by Pythagorean theorem, BC equals to:

$$BC = \sqrt{0.75^2 + 0.75^2}$$
$$BC = \sqrt{0.5625 + 0.5625}$$
$$BC = \sqrt{1.125}$$
$$BC = 1.06$$

Since $AB = 1.5\ cm$ and $BC = 1.06\ cm$, which means $AB \neq BC$, then this conclusion contradicted with the stated fact that all sides are equals.

This evaluating process did not appear to SP both in written and verbally. Some factors may cause this finding. First, SP is not used to evaluating the given solution (Araiku, Parta, & Rahardjo. Second, SP's ability to connect various geometric concepts is still lacking (Jupri, Nurlaelah, & Dahlan, 2022). Third, the SP problem-solving schema is not appropriate (Mairing, 2017).

Overall Performance

Based on the research results, it can be seen that when solving open-ended mathematical problems, students apply various problem-solving strategies. For example, AO students apply the intelligent guessing and testing and logical reasoning strategies, while SP students apply the partitioning strategy (Dym, 2005; Intaros, Inprasitha, & Srisawadi, 2014; Cordia, 2021). This difference in strategy arises for two main reasons: different problem-solving plans and different problem-solving schemes. Both of these are based on students' experiences in solving similar problems (Mairing, 2017; Araiku, Somakim, & Pratiwi, 2020). In addition, the experiences of students in everyday life also affect the process of problem solving (Harding, 2021; Hasbi, Lukito, & Sulaiman, 2019). As is well known, this research implements the *Kembang Tengah* motif as the context in which the problem is developed. The existence of students' personal knowledge of this context is very helpful for students to interpret what the questions want. The existence of meaning in the context of this problem helps students in making problem-solving plans. Differences in putting the meaning of open-ended problems lead to different problem solving plans.

Although there are differences in meaning, problem solving plans, and strategies used, open-ended mathematical problem solving has the same basis, namely the use of assumptions (Diefes-Dux, Zawojewski, & Hjalmarson, 2010; Mourtos, DeJong-Okamoto, & Rhee., 2004). The assumptions given by students in solving problems are mostly at the stage of applying the plan. Most of the application process goes according to the designed plan, but when faced with obstacles, students will use assumptions as a bridge to reach the desired conclusion. The results of the analysis showed that some of the students' assumptions were not based on proper reasoning. For example, in the case of AO, it is not explained why the size of *Kembang Tengah* is only 4 cm × 4 cm, ignoring the triangular shape. In the case of AO, there is no logical explanation for the assumption that $AB = \frac{1}{2}PC$ and $t = \frac{1}{2}AB$. The use of assumptions, of course, is not a mistake, because in solving high-level problems, logical assumptions are needed (Widana, Parwata, Parmithi, Jayantika, Sukendra, & Sumandya, 2018). However, assumptions that are not accompanied by logical reasoning will lead to inconsistent solutions and conclusions (Kumar, Edaltpanah, Jha, Broumi, & Dey, 2018). Several relevant studies have shown that in solving open-ended problems, inconsistent solutions often occur (Biber, Tuna, & Korkmaz, 2013; Haryanto & Pujiastuti, 2020). This inconsistency then causes errors in the troubleshooting process. Some of the errors identified in this study include the transformation and process skill errors (Shinariko, Saputri, Hartono, & Araiku, 2020). One example of a transformation error is when subject AO fails to compare the sizes AB, AC, and BC with the intended triangle ABC model. This is in accordance with several relevant studies that the transformation error made by high school students in solving high-level problems is quite large (Shinariko, Saputri, Hartono, & Araiku, 2020; Hadi, Retnawati, Munadi, Apino, & Wulandari, 2018). Furthermore, errors in process skills also often occur in this study, where students fail to explain the procedures or steps used in solving problems, such as calculation errors and failure to provide logical reasoning so that the conclusions given are also inaccurate. These two errors should be resolved if students carry out the evaluation process independently. This evaluation process is intended so that students can check for errors that may be made and see internal consistency (relationships at each stage of completion) and externally (related to other mathematical concepts) in the process of solving mathematical problems (Araiku, Parta, & Rahardjo, 2015; Douglas, Koro-Ljungberg, McNeill, Malcolm, & Therriault, 2012). This evaluation process was only seen verbally on both subjects during the interview. Therefore, for further research, improvements can be made in the form of affirming questions to students to carry out self-evaluations in writing. In more depth, the existence of an independent evaluation process in solving open-ended problems is closely related to students' metacognitive processes (Earl, 2006). In the metacognitive process, the first step that must be done is to make students aware of their own process (Mowling & Sims, 2021). So that in further research, it may be possible to see students' metacognitive processes in solving open-ended problems with the use of certain contexts.

Furthermore, in solving open-ended mathematical problems using a cultural context, the teacher's role is very important so that students do not make mistakes, especially because students' answers can vary according to their understanding of the problem or their culture. Therefore, it is important for teachers to actively guide students through scaffolding. In future research, it can be analyzed how appropriate scaffolding techniques to help students solve open-ended problems with the use of certain contexts.

Conclusion

The development results show that the open-ended mathematical problem developed with *Songket* motif context satisfies validity and reliability criteria. Quantitative analysis shows the validity percentage is 84.17% which means that the developed problem is valid. The validators suggest adding one task for students to sketch the desired motif and improve the formulation of the question. For interview sheet, the validation percentage was 90.28%. Hence, it was categorize as very valid. Moreover, no statement differred more than 1 for all instruments which means the products are reliable. For problem solving ability, 88.33% of students understand the problem, 59.72% of students were able to construct and 72.22% applied the plan, while 52.78% wrote consistent conclusion towards their solution. However, no student evaluate their solutions with other criteria or mathematics concepts. It is found that in solving open-ended mathematics problem with *Songket* motif context, students came up with different solution. These differences caused by various meaning and understanding towards the problem, problem solving schemes, and even personal lives. These differences influenced the strategies used by students. The similarity of open-ended mathematical problem solving process is based on assumption. However, some assumptions were not based on logical reasoning, hence, inconsistent externally and causing some mistakes in final solution. For the next research, the researcher can focus on emphasizing students' written self-evaluation in order to check and improve their solution. The researchers can also see the metacognitive process in solving open-ended mathematical problem using certain tradition. Furthermore, teachers should engaged more in using open-ended with daily context in their classroom and actively scaffold students for when they are facing obstacles in solving them.

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Conflicts of Interest

We would like to state that there is no conflict of interest in this research process and article writing in term of ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely by the authors.

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Students’ ability in solving open-ended mathematical problem with the context of Songket motif

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