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Students' problem-solving ability in solving algebra tasks using the context of Palembang

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Abstract

This descriptive research aimed to know students' problem-solving ability in arithmetic operations on algebra forms through an Indonesian realistic mathematics education, namely Pendidikan Matematika Realistik Indonesia (PMRI), approach in secondary school number 17 Palembang. The learning process, material, and assessment used were principles and characteristics of PMRI. The data collection technique was done by two students' activities and the written test to measure students' problem-solving abilities. The written test, which referred to the indicators of problem-solving ability, was given after the learning process. This study's findings indicate that Palembang's context helps students comprehend algebraic arithmetic operations. The principles and characteristics of PMRI play an essential role in enhancing students' problem-solving skills. To conclude, students develop and solve problems by modeling based on their mathematical ideas. In addition, students must be able to develop problem-solving strategies in which they employ a variety of procedures.

Keywords: Algebra, Descriptive Research, PMRI, Problem Solving, The Context of Palembang

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In everyday life, many problems are mathematical. One of the most common problem problems is algebra-related problems. Operation of algebraic form is a prerequisite material for studying some other material on Mathematics subject. This material is crucial for students. Watson (2007) suggests that to understand the symbols of algebra, students must understand the underlying operations and acknowledge and understand the notation rules with the coat of arms.

Based on the results of the research by Wardhani (2004) and Melyawati (2014) in summary, there are still some students who encounter errors and lack of understanding of the concepts in algebra, have difficulty in analyzing the problem, and lack skills in completing the operation form of algebra. In addition, the most common challenges related to understanding algebraic expressions, applying arithmetic operations in numerical and algebraic expressions, understanding the different meanings of the equals sign, and understanding variables (Jupri, Drijvers, & Van den Heuvel-Panhuizen, 2014).

Problem-solving ability refers to a person's skill to solve issues encountered in everyday life (Intaros et al., 2014). Problem-solving is one of the most fundamental goals of teaching mathematics and the most elusive (Stacey, 2005). The existing problems in education in Indonesia are the low-test results of students in the TIMSS and PISA, which are caused due to the material, the process of teaching and learning, as well as the assessment, which are inaccurate (Putri & Zulkardi, 2017a; 2018; Zulkardi et al., 2020).

According to the last three PISA tests, Indonesian pupils have insufficient knowledge of mathematics (OECD, 2014; 2016; 2019). Students have inadequate high-level skills and are unfamiliar with tackling contextual problems such as PISA tasks (Novita, Zulkardi, & Hartono, 2012; Wijaya, Panhuizen, Doorman, & Robitzsch, 2014; OECD, 2019; Putri & Zulkardi, 2018). Furthermore, the available learning tools containing PISA problems in schools and bookstores need to be increased (Wijaya, Panhuizen, & Doorman, 2015). These findings highlight the importance of solving problems that meet PISA criteria by bringing them closer to Indonesian students in learning and assessment (Zulkardi & Kohar, 2018; Nusantara et al., 2021a). Similarly, the result of TIMMS year 2011 shows that only 22% of students answered the algebra questions correctly (Rosnawati, 2013). This agreed with the research (Rimbayanto & Setyaningsih, 2015).

The ability of students to solve problems still needs to improve. Students can have a high degree of thinking ability when they learn to solve math problems in class. Hence, the ability to solve problems can be used as a benchmark for success in learning mathematics (Mairing, 2016). Problem-solving activities in learning mathematics at school have yet to be used as the main activity. They have even become an obstacle to improving students' abilities at school (Umar, 2016). Student's difficulties in formulating everyday problems into formal mathematical forms, understanding mathematical structures, and evaluating mathematical results in real-world contexts. It means low student learning outcomes in working on PISA questions (Jupri & Drijvers, 2016).

Wahyuni, Ariani, and Syahbana (2013) stated that mathematical problem-solving ability is part of the curriculum of mathematics which is very important. This is due to either the process or the result of the learning, the students are expected to gain experiences using the knowledge and skills that they already own and because it also can be used in solving the problems in everyday life. There are several stages in problem-solving, including understanding the problem, devising a plan, and carrying out the program. Mathematization is the main difficulty students often face when solving problems (Jupri & Drijvers, 2016). Students' complete tasks in stages based on their relationship to the context (Gravemeijer, 2004). In addition, students need a didactic process that can help connect mathematical concepts with their context to make problems meaningful (Gravemeijer, 2004; Doorman et al., 2007). Utilizing context in a mathematics topic can entice and inspire students to initiate learning (Van Galen & Van Eerde, 2018; Nusantara & Putri, 2018; Zulkardi & Putri, 2019). Context is a real-world phenomenon or scenario in which mathematics issues are embedded and cause students to think mathematically (Kohar et al., 2019; Zulkardi et al., 2020).

The learning curriculum should use context. Therefore, it takes a mathematical approach. In agreement with Putri, Gunawan, and Zulkardi (2017) and Feriana and Putri (2016), the approach of PMRI is one approach that complies with the curriculum and learning strategies based on student-centered learning. The problems provided contextual problems so that the student's approach was taken to understand math concepts by constructing their prior knowledge in everyday life so that the student's learning can be meaningful. PMRI is a learning approach that puts fractional operations problems close to the students and is relevant to daily life (Nova et al., 2022).

Putri (2012) states that in using a context, students would not learn directly using the formula, such as culture (Risdiyanti & Prahmana, 2018; Maryati & Prahmana, 2019). Culture has an essential role in the success of learning (Entremont, 2015). Ideas, activities, artifacts, communication, attitudes, ethics, beliefs, values, and art are some aspects of life that are included in culture (Abdullah, 2017; Laurens et al., 2018). Meanwhile, Van den Heuvel-Panhuizen and Drijvers (2014) explain that the point of view of realistic mathematics education is oriented towards constructing knowledge through learning experience-based activities. In addition, activities using cultural-based contexts use concepts in line with the learning trajectory in realistic mathematics education (Gravemeijer, 2004).

Previous research related to culture in mathematics learning has been carried out, such as Malin Kundang folklore (Putri, 2012), heritage context (Oktiningrum, Zulkardi, & Hartono, 2016), football context (Permatasari & Putri, 2018), football and table tennis contexts (Nizar, 2018), soft tennis and volleyball contexts (Jannah & Putri, 2019), long jump (Pratiwi & Putri, 2019), and COVID-19 (Nusantara et al., 2021b). In this study, researchers used the Palembang context; *Pempek* food was chosen because this context was very close to students as typical Palembang food. Another situation related to the Palembang context is the *tanjak* hat, one of the typical souvenirs from Palembang. Both situations are embedded in tasks using the PMRI approach. This reason shows the difference with previous research.

Based on the background which has been described, researchers are interested in conducting research with the formulation of the problem-solving ability: how students use the context of Palembang on material operations to calculate the form of algebra in secondary school? From the outline of the issue above, the purpose of the research is "to know the ability of problem-solving, students use the context of Palembang on material operations to calculate the form of algebra in secondary school."

METHODS

This descriptive research aimed to obtain an overview of the problem-solving capability of students through the learning process using the approach of PMRI. The study variable was students' problem-solving abilities through the learning process approach of PMRI. In this study, the ability to mathematical problem-solving of students learning mathematics implementation was observed by three indicators: understanding the problem, devising a plan, and carrying out the project.

At this stage, the preparations done by the researchers were as follows: first, create a draft research proposal seminar continued with further research; second, third, make the research permit arrangements; and finally, prepare the needed instruments, namely: drawing up the learning of mathematics by the lesson plan, the approach of PMRI, prepare the source and props required in education, prepare evaluation tools the form of the written test and the student activity sheets, test the validity of the assessment instrument.

In this study, data collection techniques were a written test in the form of an essay and an interview. Tests were conducted to measure the ability of mathematical problem-solving students based on the criteria of solving the question, which consists of three reserved. Tests were conducted after the learning process. The results of the test were tailored to indicators of problem-solving ability. The interview was done with students who became the research subject to collect data on the students' problem-solving skills. The discussion needed to be structured. This interview was done at the time after getting the final test results.

The following stages were used at the time of analyzing the data. The first was analyzing the data tests. Checking out the student's answer and giving a score were based on the following scoring criteria (Table 1).

Table 1. Problem-Solving Ability of the Scoring Criteria

Score	Understand the problem	Devising a plan	Carrying out the plan
0	Do not write down what is known and is asked in the question	Do not write the strategies used to solve at all	Could not write the resolution of a matter
1	Write down what is known and asked in the question, but only partly written in the answer sheet or less complete	The strategies used in resolving a matter less precise	Wrong at the time of writing the resolution of a matter
2	Write down what is known and asked in a question-and-answer sheet to write it into a complete and concise	The strategy used is just right and there is no error in working on it	Yet writing the resolution of the question of the complete, final answer still unknown
3			Write the settlement question correctly, but a complete step less precise and not systematic
4			Write the settlement question correctly, complete, and systematic according to what is planned

RESULTS AND DISCUSSION

The Learning Process of Algebraic Operations using the Palembang context

During the PMRI-based process of learning algebraic operations, two tasks were provided. The first task focuses on algebraic form addition, while the second act focuses on algebraic form reduction. The context of Palembang is the starting point for learning algebraic forms in both activities. Both activities utilize the Palembang context as the starting point in learning algebraic forms. In the first activity, students were given a mathematical situation involving the purchase of *pempek* packages, a traditional food in Palembang city. The second activity required students to apply mathematical reasoning to purchasing a *tanjak* hat, a typical Palembang City souvenir. These two tasks have been designed and adapted to meet the four emerging modeling levels. The development of emerging models from situational, referential, general, and formal models can be seen as the progression of students' understanding (Gravemeijer, 2004).

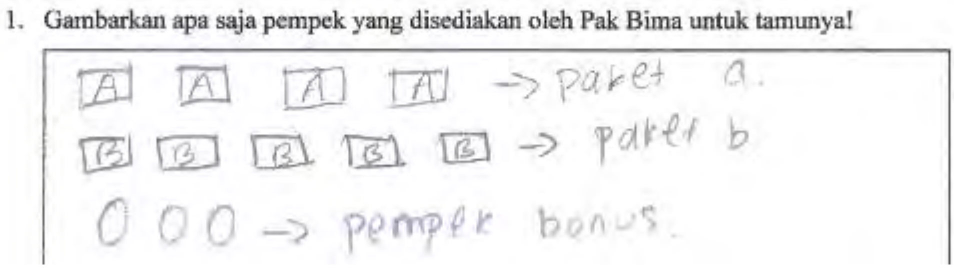
Activity 1: Addition of Algebraic Expressions

At the situational level, the process of adding algebraic forms is illustrated in Figure 1, in which students are given to complete the task. Students must determine how many packages of *pempek* they need to purchase to have enough to serve guests for two weeks.

Mr. Bima bought pempek to serve his guests for 2 weeks. Every two days, Mr. Bima always serves pempek to his guests. Mr. Bima buys pempek at his customer's place and often gets bonuses. Pempek is bought every two days, namely 4 boxes of pempek lenjer for package A, 5 boxes of pempek lenjer for package B and 3 pieces of pempek lenjer as a bonus.

Figure 1. Situational level on Activity 1

In the next emerging model level, the referential stage, students are asked to describe the number of *pempek* bought by Pak Bima for his guest (as seen in Figure 2). This stage leads students until they find meaning or how to add algebraic forms.

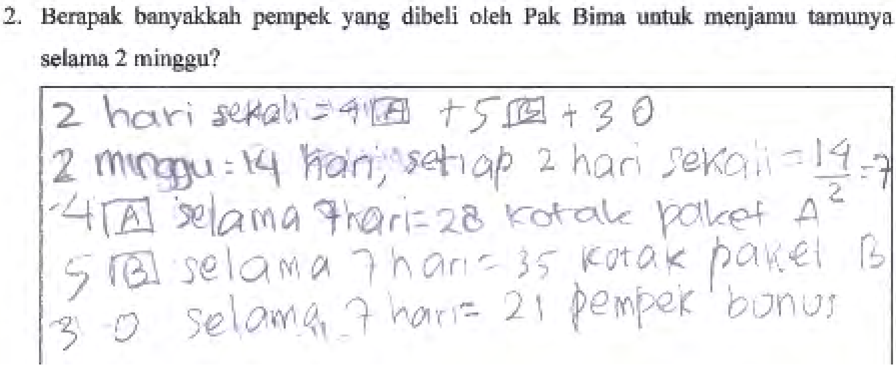

1. Gambarkan apa saja pempek yang disediakan oleh Pak Bima untuk tamunya!

A A A A -> paket a.
B B B B B -> paket b
O O O -> pempek bonus.

Translation:
Question 1.
Make sketches of *pempek* what Pak Bima prepared for his guests?

Figure 2. Referential level on Activity 1

Figure 3 demonstrates that students comprehend the presented task based on the provided information. At the general level, students were led indirectly to reasoning to determine the number of *pempek* purchases made within two weeks. Students understand that Pak Bima only serves *pempek* every other day, not every day in a row, resulting in 7 *pempek* package purchases. Therefore, each package a, b, and the bonus are added seven times.

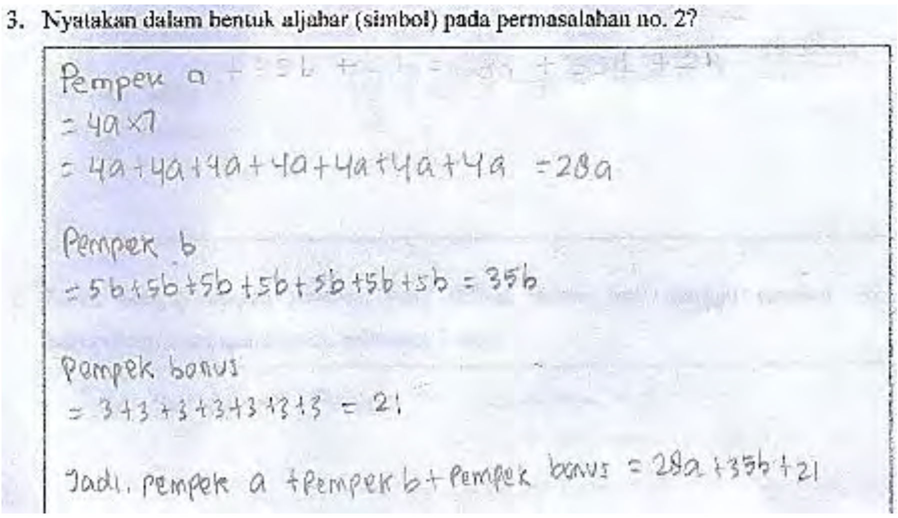

2. Berapak banyakkah pempek yang dibeli oleh Pak Bima untuk menjamu tamunya selama 2 minggu?

2 hari sekali = 4 A + 5 B + 3 O
2 minggu = 14 hari, setiap 2 hari sekali = 14/2 = 7
4 A selama 7 hari = 28 kotak paket A
5 B selama 7 hari = 35 kotak paket B
3 O selama 7 hari = 21 pempek bonus

Translation:
Question 2.
How many *pempek* did Mr. Bima buy to serve his guests for 2 weeks?
Once every 2 days = 4∆+5β+3O
2 weeks = 14 days, Once every 2 days = 14/2 = 7 (times)
4∆ (in 2 weeks) = 28 boxes of packages A
5β (in 2 weeks) =35 boxes of packaged B
3O (in 2 weeks) = 21 *pempek* (bonus)

Figure 3. General level on Activity 1

At the formal level, students are asked to calculate the purchase of *pempek* packages for two weeks in algebraic form (as illustrated in Figure 4). Students develop the mathematical symbols "a" and "b" to represent the two distinct packages. Because *pempek* packages are only available for two days, within two weeks (14 days), *pempek* packages have been purchased seven times. Thus, the existing packets are summed up seven times. Thus, students get 28a + 35b + 21 as the final solution to the problem given.


3. Nyatakan dalam bentuk aljabar (simbol) pada permasalahan no. 2?

Pempek a
= 4a x 7
= 4a + 4a + 4a + 4a + 4a + 4a + 4a = 28a

Pempek b
= 5b + 5b + 5b + 5b + 5b + 5b + 5b = 35b

Pempek bonus
= 3 + 3 + 3 + 3 + 3 + 3 + 3 = 21

Jadi, pempek a + Pempek b + Pempek bonus = 28a + 35b + 21

Translation:
Question 3.
State in algebraic form (symbols) in problem number 2?

Figure 4. Formal level on Activity 1

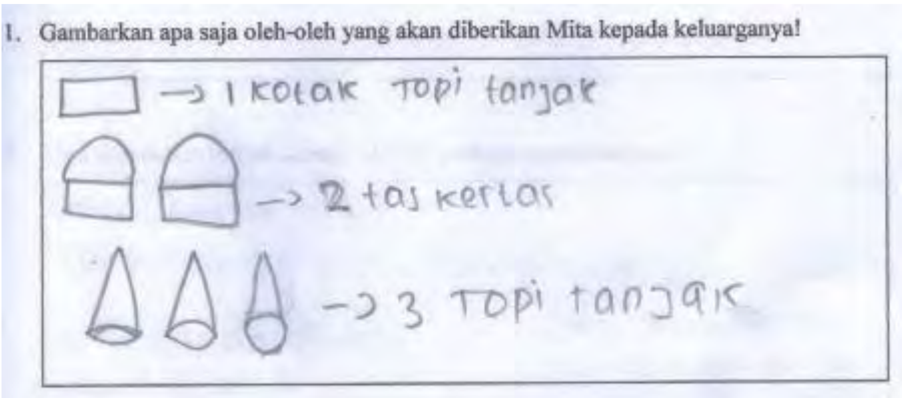
Activity 2: Subtraction of Algebraic Expressions

Figure 5 depicts the problems associated with algebraic subtraction operations from the second activity. At the situational level, students are provided with the context of a *tanjak* hat, one of the cities of Palembang's most popular souvenirs. Students must apply mathematical reasoning when purchasing *tanjak* wrapped in boxes, paper bags, or not packaged (units). In this case, students are required to calculate the number of *tanjak* hats that Mita must purchase in various situations.

Mita has purchased tanjak hats packaged in 1 box, 2 paper bags, and 3 unpackaged tanjak hats in Palembang as souvenirs for her family in Jakarta. The father and mother will be given a box of tanjak hats. The four siblings will receive the tanjak hats packaged in a paper bag, whereas the five nephews will receive the tanjak hats directly without packaging.

Figure 5. Situational level on Activity 2

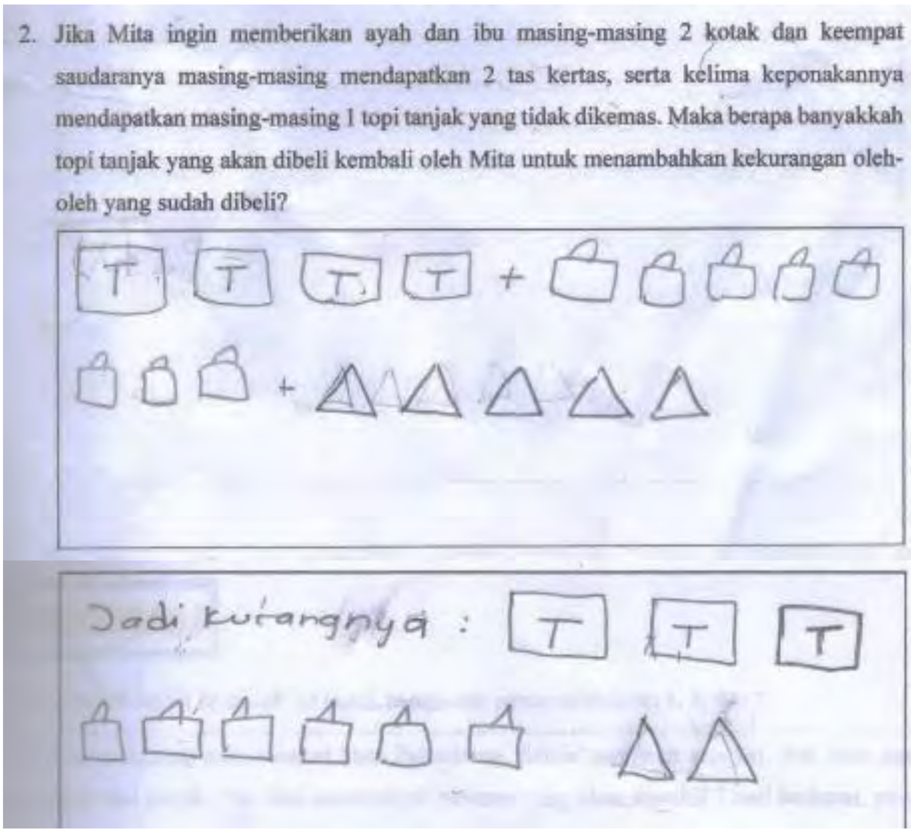
At the referential level, students must describe what souvenirs Mita purchased and will gift to her family, as illustrated in Figure 6. This level instructs students on how to find meaning or reduce algebraic expressions.



Translation:
Question 1.
Make sketches of souvenirs (*tanjak* hats) given by Mita to her family?

Figure 6. Referential level on Activity 2

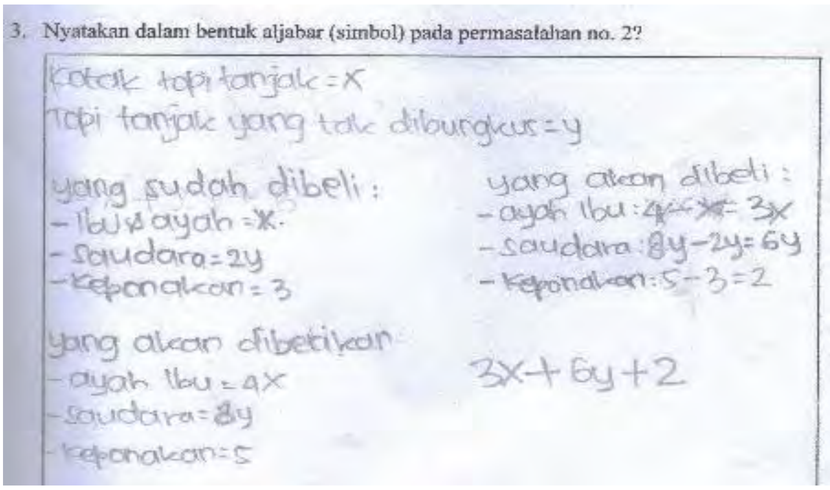
At the referential level, students sketch the required souvenirs based on question 2 (see Figure 7). Students make sketches of four squares, eight paper bags, and five triangles (as a representation of a *tanjak* hat in units). With the available souvenirs, students can determine how many *tanjak* hats they must purchase: three boxes, six paper bags, and two units of *tanjak* hats.



Translation:
Question 2.
Suppose Mita wants to present her parents with every two boxes. She will give each of her four siblings two paper bags and each of her five nephews one unpackaged *tanjak* hat. Therefore, how many *tanjak* hats will Mita purchase to make up for the shortage of souvenirs she has purchased?

Figure 7. General level on Activity 2

Figure 8 depicts the mathematical calculation procedure (algebraic subtraction operations) performed by students. At the formal level, students have utilized x and y symbols to represent *tanjak* hats in a box and units, respectively. Next, students create mathematical models relating to the souvenirs purchased. To calculate unpurchased souvenirs, students employ subtraction procedures with tribes of the same terms. Students find an algebraic form, namely 3x + 6y + 2, as a result.



Translation:
Question 3.
State in algebraic form (symbols) in problem number 2?
Tanjak hats in box = x
Unpacked *Tanjak* hats = y

Purchased souvenirs
Parents = x
Siblings = y
Nephwes = 3

Unpurchased souvenirs
Parents = 4x – x = 3x
Siblings = 8y – 2y = 6y
Nephews = 5 – 3 = 2

(Therefore), Mita need to buy 3x + 6y + 2

Figure 8. Formal level on Activity 2

Students' Problem Solving in Solving Algebraic Operations using the Palembang context

Based on the analysis of the tests, the students of Class seventh in secondary school number 17 Palembang had four categories of problem-solving ability. Seven students had problem-solving capabilities with excellent type, five had a good variety, seven had problem-solving capabilities with enough class, and ten others had problem-solving abilities with less category. However, this section focuses more on students' excellent and poor problem-solving abilities. Figure 9 depicts one of the problem-solving abilities questions given to students.

There are three square-shaped frames that have different sizes as shown below.

The first frame is 2 m smaller than the second frame and the third frame is 1.25 times larger than the second frame. The difference between the circumferences of the third and first frames is 11 m. What is the size of the side of the second frame?

Figure 9. Evaluation Test on Problem-solving Ability

Figure 9 depicts one of the problem-solving problems offered to students. The context is a square frame of varying dimensions. Students were required to compute the sides of a given frame using the given information and algebraic operations.

Of the 29 students who took the evaluation test, the results were obtained after studying the material operations of addition and subtraction to calculate algebraic form. In the good category, one of them was NS, who got 79.2; in the less category, one got 54.2 is DI. The results of the good category students' answers can be seen in Figure 10.

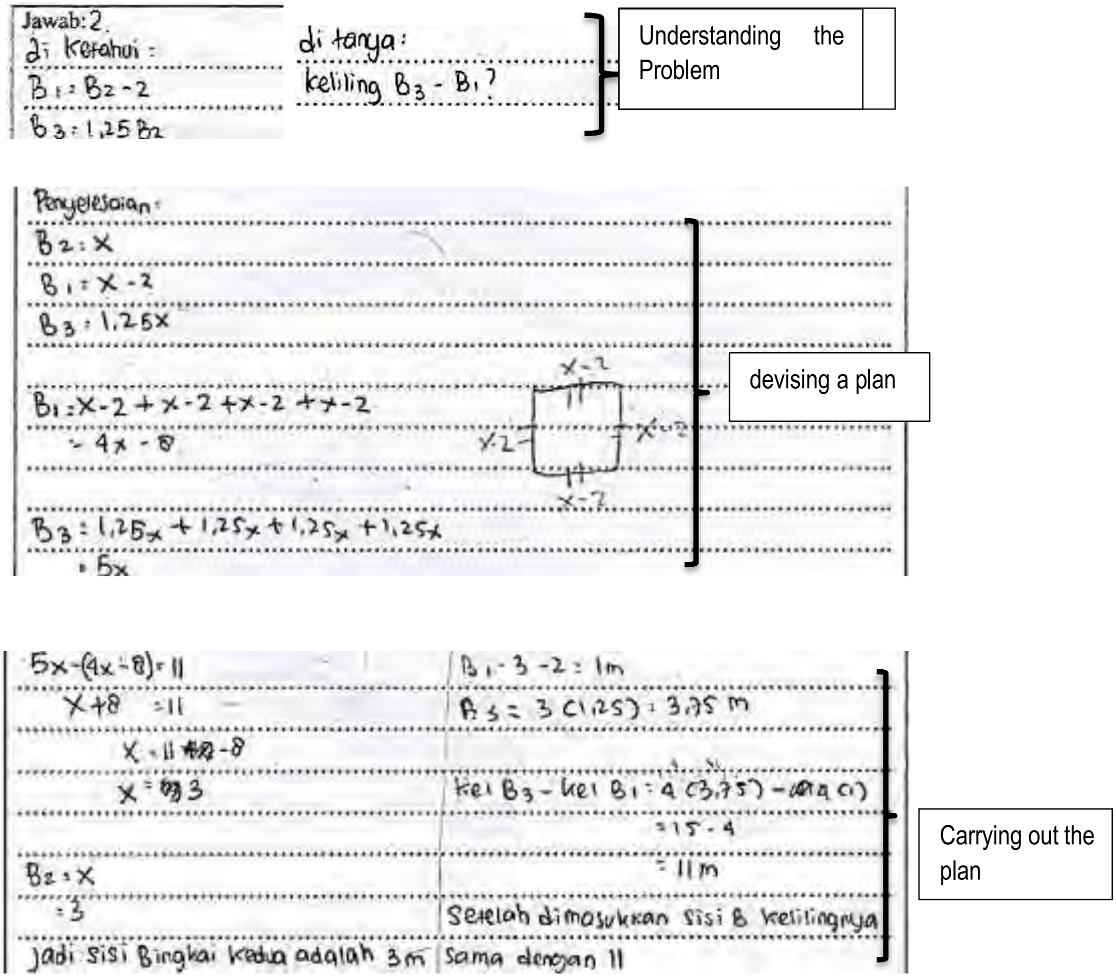


Figure 10. The Results Answer NS Category are good

Transcript 1. Conversation with NS with good category regarding the indicator of understanding the Problems

P : "What is asked for number 2?"

NS : "The size of the side frame 2"

P : "Well this is why you write the circumference of the B3-B1?" NS : "incorrect"

P : "So which one is true?"

NS : "What is the size of the side frame 2"

Transcript 2. Conversations with NS with good Category regarding the Indicator of devising a plan

P : "What is x-2+x-2+x-2+x-2?"

NS : "Their frames are shaped in the same square, all sides, plus" P : "For what is plus?"

NS : "roving"

P : "What is this (referring 5x-(4x-8))?" NS : "Frame 3 - frame 1 equals 11"

Transcript 3. Conversations with NS with good Category regarding the Indicator of carrying out the plan

P : "Why do you keep on making brackets?"

NS : "Because of the different frames"

From the above conversation, NS erred in writing down what was asked about the problem and realized his error. Therefore, NS only gets half a score of indicators of understanding the problem. At the time of the interview, NS was asked again how the process of the settlement plan on number 2 and NS could explain it correctly. On the indicator of planning completion, NS already did it well and correctly, resulting in NS getting all scores on the indicator of planning settlement. When completing the problem, NS solved number 2 precisely and accurately. NS has raised an indicator of solving the problem.

Next, to the student with less category for question number 2, there was only some understanding of the problem indicator that appeared, and the settlement strategy has yet to find completed; hence the students could not solve the problems of the reserved. The results of the less category student's answers can be seen in Figure 11.

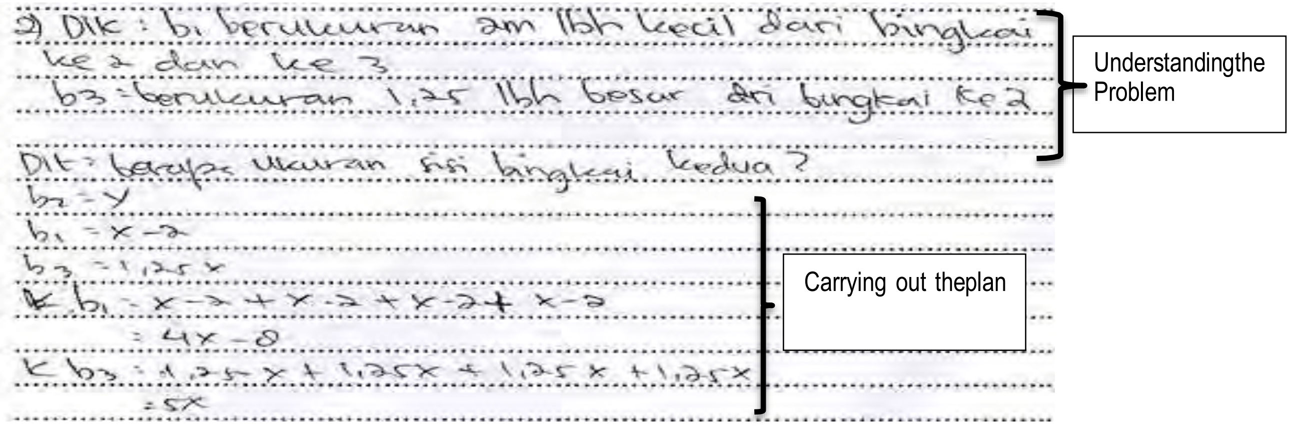


Figure 11. The Results answer DI category are less

Transcript 4. Conversations with DI with less category regarding the indicator of understanding the problems

P : "Ok, let's continue to question number 2. What can you understand from this question?"

DI : "The first frame that has a size of 2 m is smaller than the second frame, next the third frame has a size of 1.25 times larger than the second frame. The question is, I mean, the difference between the circumference of the third frame and the first frame is 11m. The question is the size of both sides of the frame."

P : "Do you think that the known point you wrote has been completed?

DI : "Not yet"

P : "What is it?"

DI : "(checking back answer sheet) the difference" P : "Why didn't you write it?"

DI : "I forgot"

Transcript 5. Conversations with DI with less category regarding the indicator of devising a plan

P : "So this is why everything is combined and why it's the same x-2, x-2, x-2, x-2?"

DI : "Because to determine the circumference, everything is added"

P : "Why are all x-2?"
DI : "Because it is to determine the circumference of a square frame"
P : "So why didn't you finish answering question number 2?"
DI : "I was running out of time"

From the above-stated conversation, DI could explain what was known and was asked in question 2. Because DI needed to write the known point, at the time of the interview, DI said that he forgot to write down the difference between frames three and one. Moreover, DI still needs to finish answering question number 2 because he needs more time. DI is still required to complete the strategies used to solve problem number 2. However, the initial process of DI was that he did it correctly. Based on the conclusions from the results of the answers and interview, DI got a total score of 2. On the indicators of understanding the problem and planning completion, he scored 1.

In analyzing students' test answers, the achievement of students' problem-solving ability scores was obtained based on indicators. The accomplishment of the emergence of the charge indicators included: question No. 1, the appearance of indicators to understand the problem of 28 students, the occurrence of planning completion indicators of 29 students, and the formation of resolving the problems indicator of 29 students. For question number 2, there were the occurrence of understanding the problem indicator of 29 students, the occurrence of planning completion indicator of 28 students, and the appearance of resolving the issue indicator of 17 students. For question number 3, there were the occurrence of understanding the problem indicator of 18 students, the occurrence of planning completion indicator of 27 students, and the appearance of resolving the issue indicator of 4 students.

From the results obtained, the settlement plan indicator was an indicator that often appeared, and the list was the indicator that resolved the issue. From the results of the student's answer sheets, there were still many students who still needed to do the workaround entirely and correctly, in which the indicator of solving the problem still needed to be achieved. This was in line with the results of the research of Nirmalitasari (2012) that the level of student's ability profile was in doing problem-solving plan categories including sufficient and less, whereas for lower-level students' ability profile, in doing types including less of the problem-solving plan.

Understanding the problem indicator appeared lower than the planning settlement indicator because most students needed to write what was known of the problem and what was asked of the reserved; some students mostly directly sought settlement strategies in answering the question. This was because students needed clarification and found it challenging to understand the question, resulting in many students writing down what was known and asking incompletely. This result was in line with Sulistiyorini (2016) research that it took much work for students to understand the problems because they needed to become more accustomed to the questions using the phases of Polya. Students still needed clarification when they wrote symbols. They still needed to understand the concept of the material that was taught. They needed to be more meticulous in regulating the quality process and impressed desultory.

When the time of the learning process using PMRI approached, students were directed to relate it to the real, making it easier for them to understand. Learning PMRI led the students to use concrete models and formal models. Putri and Zulkardi (2017b) reveal that the material used the approach of Realistic Mathematics Education, i.e., the context of an actual situation. However, students should be guided to understand math concepts towards various contextual problems. This result was in line with the research of Sarbiyono (2016), Putri and Zulkardi (2017b; 2018), and Rahayu and Putri (2018) that the ability of mathematical problem-solving of students who obtain realistic mathematics learning is higher than the mathematical problem-solving of students who obtain the conventional learning.

Table 2. Principles of PMRI based student activity sheets

Guided reinvention and didactical phenomenology	Progressive mathematization	Self-developed models
At the time of learning, teachers gave reserve in SAS 1 (Student Activity Sheets 1) and SAS 2 from different activities based on everyday life. The teacher asked the students to understand the issues that matter and find their skills. On the SAS there was a context (given problem) that students would carry out. Through the context, there would be guided by the questions.	At the time of learning, there were SAS (Student Activity Sheets) that the students did. SAS were materials that contained the actual state of the students through math problem stages before formal. In formal mathematics in SAS, students were asked to solve problems using symbols.	At the time of learning, there were SAS (Student Activity Sheets) continuing problems carried out by students. Students, in this case, were given a problem to be resolved by creating their model. Developing the model itself links students of the actual situation to the concrete or from informal to formal mathematics. In this situation, the students' model was close to real life, as described in the implementation of learning.

Learning is carried out by the principles of PMRI-based student activity sheets (Table 2), as of its characteristics: the use of context. This context was used at the time of learning, i.e., the context of Palembang. The context was displayed with images of SAS (Student Activity Sheets) machined students. For the use of models for progressive mathematization students, students were assigned to conduct such activities using the models they made themselves (use of models). In utilizing the construction students' results, teachers gave students the freedom to answer the question in SAS. Interactivity, after a discussion, the teacher lets the group representative present the results of the discussions of the Group respectively. Intertwining, the teacher delivered the linkages in the material form of the algebra to calculate operating with other materials such as the material number or the material to be learned next operation calculates the algebraic form of multiplication and division.

CONCLUSION

Understanding the problems is an essential part of problem-solving. The introduction of the Palembang context supports students in better understanding algebraic operations. Learning algebraic operations is more meaningful for students since the situation presented is part of their culture. The emergent progressive mathematization process in PMRI helps students improve problem-solving skills, such as devising and carrying out the plan. However, the challenge for future studies is to enhance students' problem-solving skills when looking backward. This idea needs significant consideration in the form of a learning trajectory that can hone these skills.

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Declarations

Author Contribution	:	RIIP: Conceptualization, Writing - Original Draft, Editing and Visualization, Methodology. Z: Resources, Data Curation, Validation, Writing - Review & Editing, Formal analysis. ADR: Methodology, Editing, and Supervision.
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Conflict of Interest	:	The authors declare no conflict of interest.

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