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VOCATIONAL HIGH SCHOOL STUDENTS' ABILITY TO SOLVE WORD PROBLEMS IN THE TOPIC OF LINEAR EQUATIONS SYSTEM WITH TWO VARIABLES

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Abstract

Problem-solving is a mathematical skill that students need to develop to solve challenges in everyday life. However, this ability has yet to be fully mastered by students. Therefore, this study analyzes the problem-solving skills of ten-grade private Vocational High School students in Sragen, Central Java, Indonesia, particularly in the Linear Equations System with Two Variables (LESTV). This study used a descriptive qualitative method involving 25 Computer and Network Engineering students (CNE). The problem-solving indicators used are understanding the problem, devising a plan, carrying out the plan, and looking back. This study grouped students into three levels based on the results of the Mid Semester Assessment (MSA) of students' initial abilities, namely low, medium, and high initial ability levels. Based on the analysis, this study indicates that students with low initial ability levels are less able to understand problems and the other stages. Students with a moderate level of initial ability can meet the indicators of understanding the problem and devising a plan. Students with a high level of initial ability fulfill all problem-solving indicators. Students have been able to understand problems, devise a plan, carry out the plan, and look back. Students with a high level of initial ability can analyze and conclude the results of the answers correctly, accompanied by re-examining the solutions they have obtained.

Keywords: Problem-solving Skills, Polya Steps, Linear Equations System with Two Variables, Initial Ability

Abstrak

Pemecahan masalah merupakan keterampilan matematika yang perlu dikembangkan siswa untuk memecahkan tantangan dalam kehidupan sehari-hari. Namun, kemampuan ini belum sepenuhnya dikuasai oleh siswa. Oleh karena itu, penelitian ini menganalisis kemampuan pemecahan masalah siswa SMK swasta kelas X di Sragen, Jawa Tengah, Indonesia, khususnya pada materi Sistem Persamaan Linier Dua Variabel (SPLDV). Penelitian ini menggunakan metode deskriptif kualitatif yang melibatkan 25 siswa Teknik Komputer dan Jaringan (TKJ). Indikator pemecahan masalah yang digunakan adalah memahami masalah, menyusun rencana, melaksanakan rencana, dan memeriksa kembali. Penelitian ini mengelompokkan siswa menjadi tiga tingkatan berdasarkan hasil Penilaian Tengah Semester yaitu tingkat kemampuan awal rendah, sedang, dan tinggi. Berdasarkan analisis, penelitian ini menunjukkan bahwa siswa dengan tingkat kemampuan awal rendah kurang mampu memahami masalah dan tahapan lainnya. Siswa dengan tingkat kemampuan awal sedang dapat memenuhi indikator memahami masalah dan menyusun rencana. Siswa dengan kemampuan awal tingkat tinggi memenuhi semua indikator pemecahan masalah. Siswa telah mampu memahami masalah, menyusun rencana, melaksanakan rencana, dan memeriksa kembali. Siswa dengan tingkat kemampuan awal yang tinggi dapat menganalisis dan menyimpulkan hasil jawaban dengan benar, disertai dengan memeriksa kembali solusi yang telah diperolehnya.

Kata kunci: Kemampuan Pemecahan Masalah, Langkah Polya, Sistem Persamaan Linear Dua Variabel, Kemampuan Awal Matematis

INTRODUCTION

Problem-solving is an attempt to find a solution that consists of a series of strategies (Purba et al., 2021). Students have different problem-solving abilities (Sutriyono et al., 2019).

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Through problem-solving strategies, students can understand complex problems and develop a plan to finally determine solutions to these complex problems (Rambe & Afri, 2020).

According to Yulianto et al. (2019) the math problem-solving ability of Indonesian students still needs to improve. This finding is evidenced by the results of the Program for International Student Assessment (PISA) test according to the OECD (2018), which shows that students' mathematical problem-solving abilities are still meager. Indonesian students' math scores rank 7th, with an average score of 379 points, meaning that Indonesia ranks 72nd out of 78 countries. This score is far when compared to the international score of 489. This score had decreased compared to the 2015 test when Indonesian students obtained an average score of 386 on the math test. Students' not-yet-optimal problem-solving ability is also shown by the way students solve math problems (Irianti, 2020). Furthermore, Umainah et al. (2020) explained that the percentage of student problem-solving acquisition needed to match the indicators.

Annisa et al. (2021) state that mathematical problem-solving skills help solve real-life problems. Mathematical problem-solving abilities help students learn mathematics and are very important in other learning and everyday life (Novianti et al., 2020). According to Asni et al. (2021), students can discover the mathematical concepts being studied through problem-solving abilities. The word problems are then included in everyday problems so students can easily understand them (Wusananto et al., 2022). Students must change word problems into mathematical problems and solve them according to mathematical procedures, one of which uses the Polya theory (Widodo, 2016).

Completing mathematics word problems must be balanced with sufficient reasoning abilities (Anggraini & Rejeki, 2021). The stages of the problem-solving process proposed by Polya (1973) include: (1) understanding the problem, (2) devising a plan, (3) carrying out the plan, and (4) looking back, as described in Table 1.

Table 1. Indicators of Mathematical Problem Solving Ability

Polya Steps	Descriptions
Understanding the Problem	Students can identify what they know from the problem and determine the unknown from the problem.
Devising a Plan	Students can identify appropriate problem-solving strategies in solving problems.
Carrying Out the Plan	Students can solve problems by following the problem-solving plan.
Looking Back	Students can re-check the answers they have obtained to avoid contradictions with the questions. There are four crucial guidelines for carrying out this step, namely:

1. Connecting the results obtained with the questions asked,
2. Interpreting the answers obtained,
3. Determine if there is another way to solve the problem, and
4. Identify whether there are answers or other appropriate results.

One of the topics in mathematics that applies word problems is the Linear Equations System with Two Variables (LESTV). School word problems are made to hone mathematical problem-solving (Sari & Rejeki, 2021). According to Resta & Munawaroh (2018), the error rate of students in solving LESTV questions in word problems is still relatively high. This error is because the low ability of students to understand LESTV word problems makes them feel difficult (Agustini & Pujiastuti, 2020). Word problems are a form of problem that is often found in math problems that are closely related to problems in everyday life (Jumiati & Zanthy, 2020).

The research results by Mutaqin et al. (2022) stated that all class IX Islamic Junior High School (Madrasah Tsanawiyah) students could solve LESTV questions up to the third stage of the problem-solving indicator. However, most were unable to work until the fourth indicator stage. Meanwhile, Irianti (2020) shows that grade eight students with high reasoning abilities on LESTV topics can complete each stage of the Polya steps. Students with moderate abilities do not carry out the looking back. Students with low reasoning abilities are unable to solve problems with Polya steps. Likewise, Purnamasari & Setiawan's research (2019) concluded that grade eight students with high initial mathematical ability groups could solve LESTV problems up to the third indicator better than students in the middle and lower early mathematical ability groups. However, all students still need to gain mastery of the fourth indicator, namely, looking back. Previous research there has yet to be research that discusses problem-solving abilities in LESTV material at the Vocational High School (VHS) level.

The results of research by Riam et al. (2020) showed differences in the mathematical problem-solving abilities of grade ten VHS students in the matter of sine and cosine rules based on their level of initial mathematical ability. The previous research discussed problem-solving skills in VHS with the topic of sine and cosine rules, while the research will be carried out using LESTV material. Based on this description, this study aims to analyze the problem-solving abilities of grade ten VHS students in solving word problems on the LESTV topic in terms of student's initial abilities.

METHODS

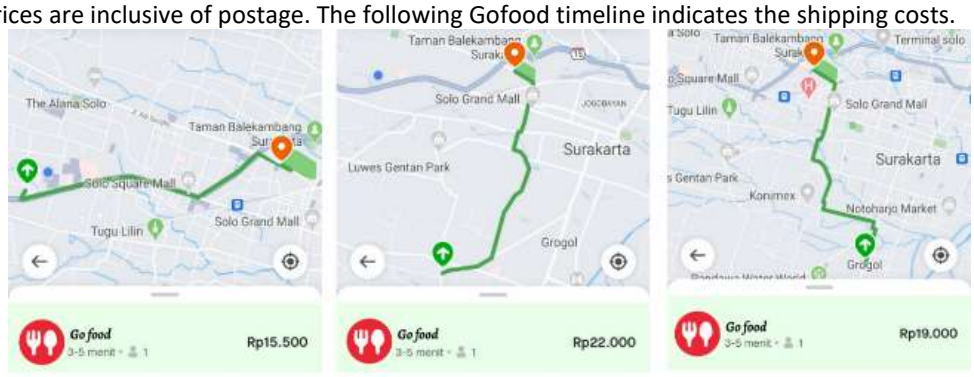
This study used a descriptive qualitative method to describe the problem-solving skills of grade ten VHS students based on Polya's theory of solving word problems on a LESTV topic regarding initial abilities. This research was conducted at a private VHS in Sragen, Central Java, Indonesia. The subjects of this study were students of grade ten Computer and Network Engineering (CNE), consisting of 25 students. The subject was then taken by six students based on their Mid Semester Assessment (MSA) results, which were grouped into low, medium, and high initial ability levels.

The researcher's data collection procedure was to group students into initial ability categories based on MSA scores. Next, the researcher gave LESTV comprehension essay tests to students. After getting the results of students' work, researchers will analyze problem-solving abilities according to the categories of students' initial abilities in understanding the problem, devising a plan, carrying out the plan, and looking back. In the final step, the researcher will conduct interviews to reinforce the analysis results and draw conclusions.

Table 2. Mathematics Problem-Solving Test

No	Problem
1	Septian and Jamal are Network Administrators who work at the Semarang head office. They were assigned to repair computer network infrastructure and hardware spread across several cities. The computer point they must repair is indicated by the following map, along with the calculated distance from their office center in Semarang.  The total distance traveled by Septian and Jamal is 186 km. Meanwhile, twice Septian's distance minus three times Jamal's distance is 77 km. Determine the destination of Septian and Jamal based on the distance provided on the maps!
2	Putri, Mita, and Anna are friends who are students at a school in the city of Sukoharjo. The three friends will celebrate Anna's birthday this Saturday night by having dinner together. However, due to the pandemic, the celebration was carried out via video call at each other's homes. They agreed to buy food at KFC Manahan through the Go Food application because there was a duty-free promo. Putri bought a crispy burger and two-star fruit floats with a total price of IDR

No	Problem
	46,000. Mita bought two crispy burgers and a star fruit float with a total price of IDR 65,000. All prices are inclusive of postage. The following Gofood timeline indicates the shipping costs.



Putri **Mita** **Anna**

	Anna bought four crispy burgers and three-star fruit floats to celebrate at home with her family. Determine what total price Anna will have to pay.

The instrument used in this study is a mathematical problem-solving ability test in the LESTV topic, which was adapted from Aini & Mukhlis (2020) and validated. The data collection techniques in this study are documentation and interviews. Data analysis techniques used in this study include data collection, data reduction, data presentation, and decision-making or verification. In addition, in this study, the validity of the data used by researchers is triangulation. According to Sugiyono (2017), the triangulation used in this study is method triangulation, namely by comparing and checking the credibility of information obtained by comparing student work data with interview data.

RESULTS AND DISCUSSION

The grouping of students is based on their initial abilities, as seen from the MSA scores. It is categorized into three different levels based on a formula with the student's average score and standard deviation, as shown in Table 3.

Table 3. Criteria for grouping research subjects

Interval	Category
MSA $< \mathbf{78}$	Low
$\mathbf{78} \leq$ MSA $\leq \mathbf{86}$	Medium
MSA $> \mathbf{86}$	High

Based on these level criteria, the data recapitulation of students' initial abilities is obtained in Table 4. After the students were grouped according to their level of initial mathematics ability, then all students of grade ten CNE worked on the mathematics problem-solving test with an allotted time of 45 minutes. The questions measure students' problem-solving abilities in the LESTV topic.

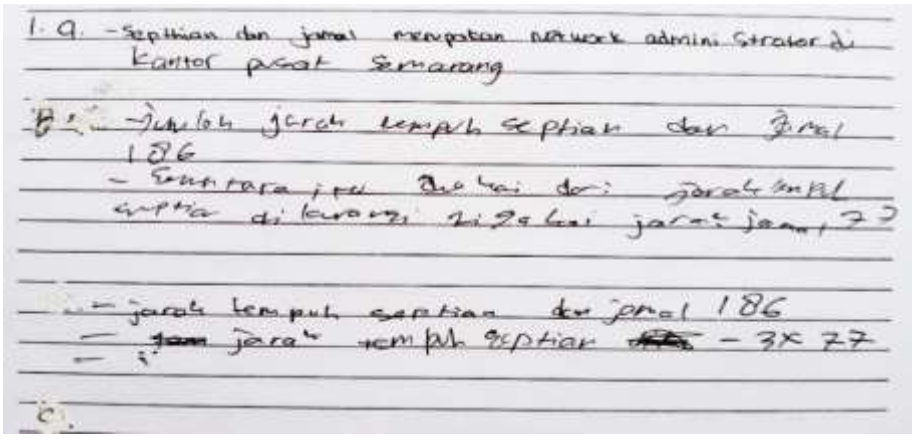
Table 4. Recapitulation of Students' Initial Ability Data

Category	Percentage	Frequency
Low	44%	11
Medium	32%	8
High	24%	6
Total	100%	25

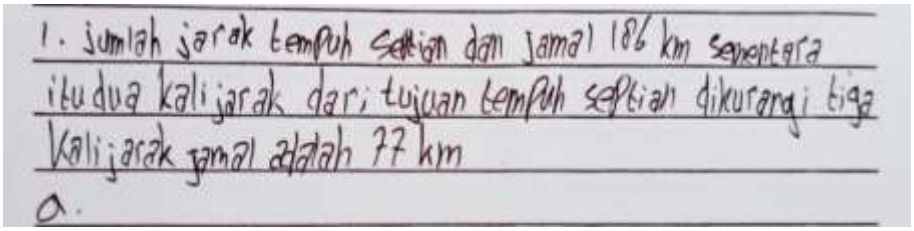
Students are asked to answer the questions by writing down the available information. Next, changing the math word problems into the form of a mathematical model is then carried out using LESTV. This was done to make it easier for researchers to analyze students' mathematical problem-solving abilities through the problem-solving ability indicators listed in Table 1. After the test results have been obtained and analyzed, the interviewees are conducted to reinforce the analysis results. The results obtained were that the three students had different initial abilities, namely low, medium, and high initial ability levels. Students with low initial ability levels were coded L1 and L2, students with moderate ability levels were coded M1 and M2, and students with high ability levels were coded H1 and H2.

Problem-Solving Skills of Students with Low Initial Ability Level

Students with low initial ability levels have not yet been able to fulfill all problem-solving indicators. Students with a low initial ability must write down known information and ask about the problems in the questions completely and accurately. In addition, students need help to write down plans for solving problems, carry out plans, and make conclusions from the results of these problems. Figure 3 and Figure 4 shows the written works of those two students.



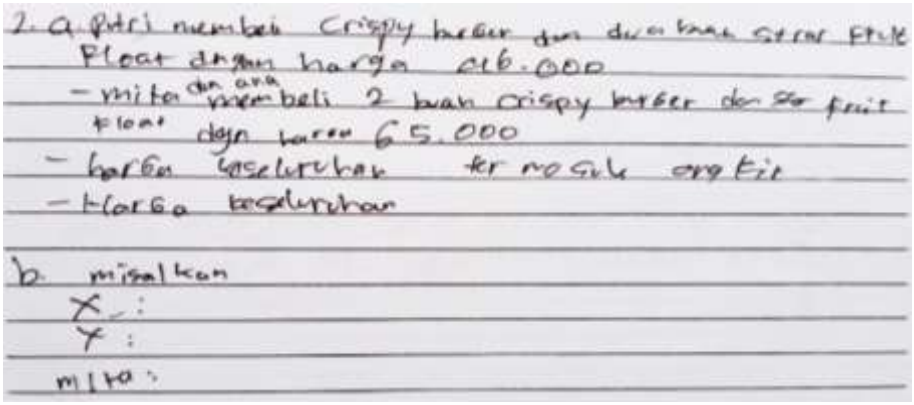
L1



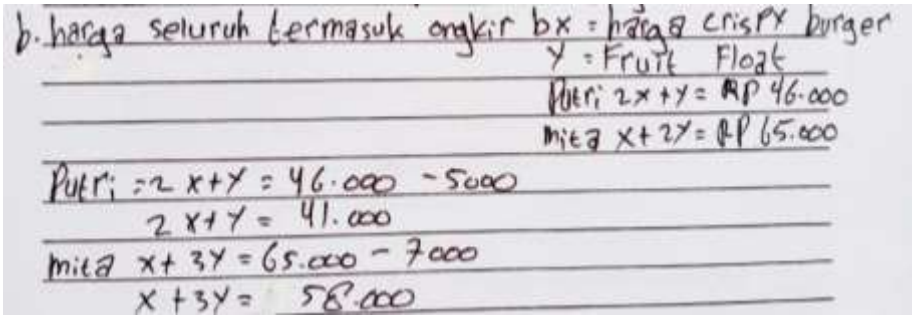
L2

Figure 3. The Written Works of L1 and L2 on Problem Number 1

In Figure 3, it can be seen that subjects L1 and L2 are less able to understand the current problem information. The subject wrote down what was known even though it needed to be completed but did not write down what was asked in the problem. From the results of the student's answers, it is evident that question number one needed to be adequately solved. Subjects L1 and L2 had difficulty exemplifying the search terms in the form of variables, changing word problems into mathematical models, and performing LESTV operations.



L1



L2

Figure 4. The Written Works of L1 and L2 on Problem Number 2

Likewise, in question number two, students with a low level of initial ability have yet to be able to solve the problem up to the completion and conclusion. Judging from the answer to question number two from subject L1, they needed help understanding the concept of

LESTV, so it took much work to solve the problem. The same thing happened to subject L2, but subject L2 could still identify problems up to the mathematical model example stage. However, they have yet to be able to apply the mathematical model and have difficulty understanding the next steps. Based on the results of the interviews, it was found that students needed help understanding the questions because the students themselves needed to understand the LESTV concept.

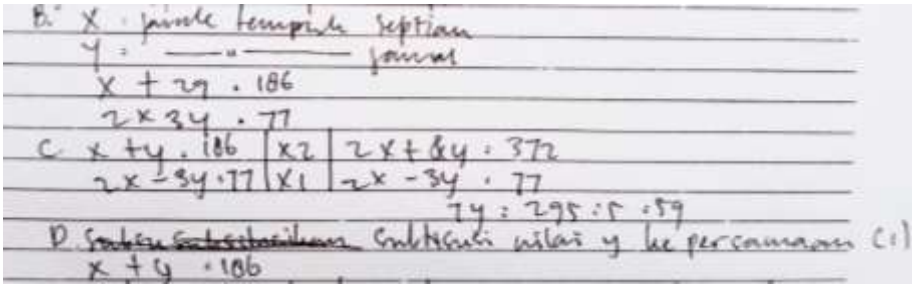
R : "How do you plan the steps to solve the problem?"

L : "I actually don't understand how to solve the problem, so I rewrite the information in each sentence where there are numbers in the problem onto the answer sheet."

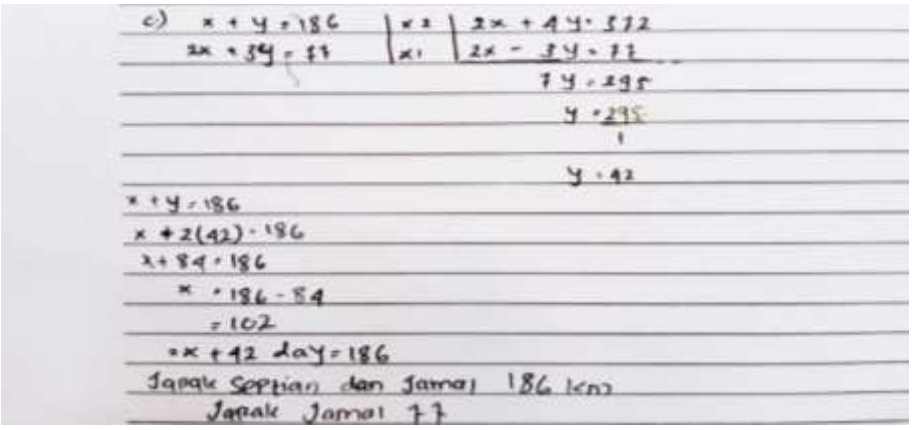
Based on the analysis results and interviews conducted with students with low initial ability levels, it can be concluded that students with low initial ability levels cannot fulfill problem-solving indicators. Students only meet the indicators of understanding the problem because they can understand the information contained in the problem and write it down. Students with a low initial ability need help deciding on variable examples and correctly changing the problem into a mathematical model. In addition, students have yet to be able to determine problem-solving strategies or find conclusions about the results of their work.

Problem-Solving Skills of Students with Moderate Initial Ability Level

Students with a moderate level of initial ability are only able to fulfill a few indicators of problem solving. M1 and M2 subjects could write down known information and ask about the problems in the questions correctly. Subjects can plan strategies to solve problems but they must be completed and precise. The subject ran out of time working on the questions, so they arrived at a later stage of completion and conclusion.



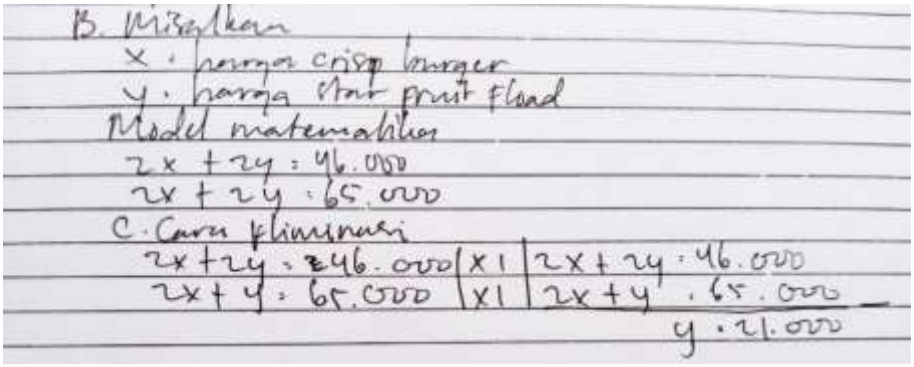
M1



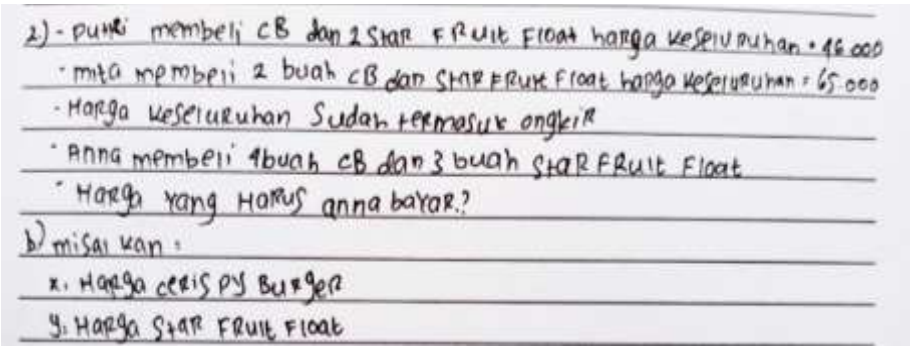
M2

Figure 5. The Written Works of M1 and M2 on Problem Number 1

In Figure 5, question number one, subjects M1 and M2, can understand the problem well. Subjects can also make a settlement plan, the distance traveled by Septian and Jamal, and then make a mathematical model from the information they get. The subject is also able to write down a problem-solving strategy. M1 subjects cannot write down the results of their work to the end. Meanwhile, Subject M2 wrote down the settlement results to the conclusion stage. However, he made a mistake during the elimination, so the results and conclusions must be corrected.



M1



M2

Figure 6. The Written Works of M1 and M2 on Problem Number 2

Likewise, subjects with moderate initial ability levels have yet to complete problem-solving number two to the results and conclusions in question two. Judging from the answers to question number two from subjects M1 and M2, they could write down information and what was asked and known from the questions. Subjects can also make a mathematical model formulation of the price of food ordered. However, in the next stage, the subject still needs clarification about completing elimination and substitution. So they run out of time, and the answer needs to find a solution.

During the interview, the subjects stated that they could understand the problem, but they found it challenging to make a mathematical model because the questions were in the form of word problems, so they spent a long time at that stage. Subjects also admitted that they found it challenging to do LESTV elimination and substitution after making plans and wondered if their answers were wrong.

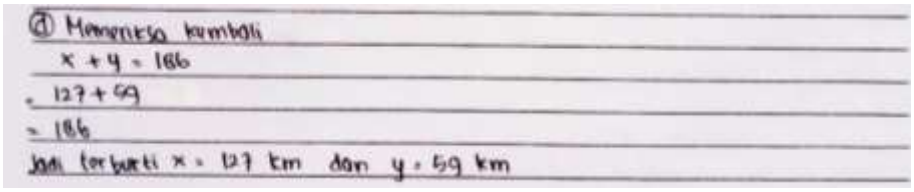
R : "Did you find it difficult to understand the questions given?"

M : "I had quite a hard time understanding word problems, so it was quite difficult for me to be able to determine the variables from the mathematical model."

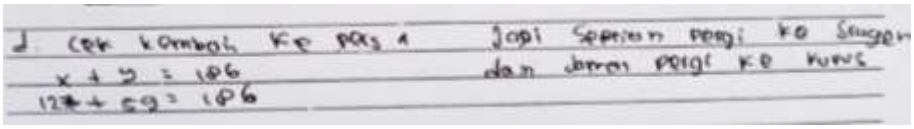
Based on the analysis of the results of the work on the questions and interviews, students at the initial ability level can meet the indicators of understanding the problem and the indicator of planning a solution. However, they have been unable to carry out the solution correctly and still need to be corrected in determining the mathematical model to use. In addition, students at the intermediate level of ability have yet to be able to write down the conclusion stage of the results of the completion that has been done.

Problem-Solving Skills of Students with High Initial Ability Level

Students with a high initial ability can solve problem-solving questions properly and correctly. Subjects H1 and H2 can also fulfill all problem-solving indicators from indicator one to indicator 4, namely understanding the problem, devising a plan, carrying out the plan, and looking back. In working on questions, students with high ability levels can solve all questions by relying on their abilities.



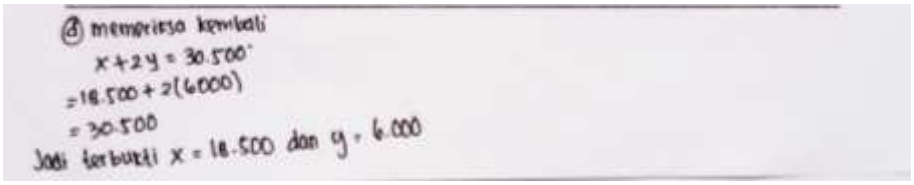
H1



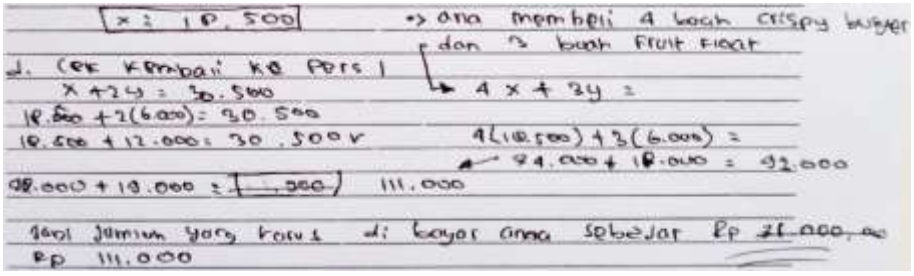
H2

Figure 7. The Written Works of H1 and H2 on Problem Number 1

Based on Figure 7, it can be seen that the answers to LESTV question number one from subjects H1 and H2 were able to write down complete information on what was asked and known in the questions. That way, the subject has met the indicators of problem-solving, namely, understanding the problem. Subjects are also able to make plans which can turn questions into mathematical models while at the same time being able to write solutions to solving problems entirely and precisely. In addition, the subject can also analyze and write a conclusion in detail the results of problem-solving. In this section, the subject has fulfilled the problem-solving indicators: planning and carrying out the plan. In the last stage of the work, the subject still had time to look back the results of his answers, so the subject had fulfilled the looking back indicator.



H1



H2

Figure 8. The Written Works of H1 and H2 on Problem Number 2

Just like in question number one, subjects with a high initial ability could solve problem number two properly and correctly. Subjects H1 and H2 can fulfill all indicators of problem-solving coherently and precisely. Judging from the answers to question number two from subjects H1 and H2, they could write down information and what was asked and known from the questions. The subject is also able to formulate a mathematical model as well as write down the solution to solving the problem entirely and accurately while at the same time making the correct conclusion at the end of his work.

The subject also still had time to check the results of the answers to ensure the correctness of the results of his work. During the interview, the subject can explain in detail the information in question two, what is known and asked. The subject explained the problem-solving in detail, starting with the cost of the food ordered, writing down the mathematical model for doing elimination and substitution, solving steps, concluding the results, and checking answers.

R : Are you sure your answer is correct? In what way did you check your answer? “

H : "I re-check my answers by plugging the x and y values into equation 1 because the result is the same. My answer is correct."

R : "Choose one of the two questions. Then what steps did you take to solve it?"

H : "I chose number 2. In the first step, I wrote down the information from the question (reading the answers). Next, I assume x and y and then make a mathematical model. Because the total price, including shipping, must be reduced first, x is eliminated, and y is substituted into equation 2. After meeting x and y, find the price Anna must pay plus shipping. So, Anna's total price is IDR 111,000. "

Based on the results of the analysis of answers and interviews with students with a high level of initial ability, it can be concluded that students with a high initial ability level are used to working on a system of linear equations in two variables in the form of a story so that they can solve problems correctly and do not lack time to do them. Students with a high level of initial ability fulfill all problem-solving indicators. Students can understand the available information and ask about the problem to understand the problem. On the planning completion indicator, students can solve problems by planning strategies and can explain the steps. On the indicators of carrying out the plan, students can analyze and conclude the

results of the problem correctly. On the looking back indicator, students can prove that the results of their answers are correct.

Table 5. Analysis of students' problem-solving abilities

Indicators	Question	Subject					
		L1	L2	M1	M2	H1	H2
Understanding the Problem	1	✓	✓	✓	✓	✓	✓
	2	✓	✓	✓	✓	✓	✓
Devising a Plan	1			✓	✓	✓	✓
	2		✓	✓	✓	✓	✓
Carrying Out the Plan	1				✓	✓	✓
	2					✓	✓
Looking Back	1					✓	✓
	2					✓	✓

This study shows that the problem-solving ability of grade X CNE students in solving word problems on the material of a system of linear equations in two variables is still diverse; there are students with low, medium, and high initial ability levels. Students with low initial ability levels only fulfill the indicator of understanding the problem. Students with moderate initial ability levels fulfill two indicators, namely understanding the problem and devising a plan, while students with high initial ability levels fulfill all indicators of mathematical problem-solving. This shows that high-level students' initial mathematical ability is better than those with medium and low initial ability levels. Also, students with medium initial mathematical ability levels are better than those with low ones.

These findings are in line with Nurhasanah & Adirakasiwi (2019) that the mathematical problem-solving ability of junior high school students on solid geometric figures shows that the high category of students' problem-solving ability has been able to fulfill all problem-solving indicators, the medium category of students' problem-solving ability is only able to fulfill three indicators in addition to planning problem solving, but in solving, it is only able to write the conclusion. The low category of students' problem-solving ability can only fulfill some problem-solving indicators. According to the results of this study, students' ability to solve problems at the stage of understanding the problem, devising a plan, and carrying out the plan was successful. However, some students could have shown better results when re-examining their answers (Rambe & Afri, 2020). Based on previous research, it can be concluded that only a tiny proportion of students who have a high initial ability can answer questions up to the indicator of checking back correctly.

It was generally believed that learning mathematics through word problems requires more understanding than other problems. The completion stage is also not easy to stage because the completion process only depends on the result but also looks at the steps for solving it (Nugroho & Sutarni, 2017). However, as Fadilah & Haerudin (2022) said, students are expected to have good mathematical problem-solving skills because this significantly influences the learning outcomes obtained by students. In this case, the need for a way to overcome students understand the problems in word problems such as applying the steps: (1) reading the questions repeatedly so that it is easy to understand words as well as sentences, (2) identifying what is known and what is asked of the problem, (3) setting aside inappropriate information with problems, and (4) focus on the problems only (Aini & Mukhlis, 2020).

The results of this study are expected to be used as evaluation material for teachers to innovate in learning so that they can continue to improve students' problem-solving abilities. Based on this, the researcher recommends further research related to how to develop more broadly related solutions to problem-solving skills in improving solving word problems in the material of a system of linear equations in two variables.

CONCLUSION

Students with a low level of initial ability can only fulfill one indicator of problem-solving, namely understanding the problem. Students with a low initial ability can only write down the information in the problem, even though what is written needs to be corrected. Students with a moderate level of initial ability can meet the indicators of understanding the problem and planning a solution. However, students with medium initial ability levels still needed to improve at writing down complete information, determining the variables, for example, and determining the correct mathematical model from the problem information. Students with a high level of initial ability meet all indicators of problem-solving. Students have been able to solve problems by planning strategies and being able to explain the steps. In addition, students with a high level of initial ability can analyze and conclude the results of the problem correctly and check their answers without running out of time.

The conclusion implies the importance of strengthening students' problem-solving ability in solving mathematics word problems. Moreover, more effort is needed to increase students' problem-solving skills with low and moderate levels of mathematics initial ability.

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