Analysis of high school students' mathematical problem-solving abilities on matrix content

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Abstract
This research has the aim or purpose of analyzing high school students' mathematical problem-solving abilities on matrix content using indicators consisting of 4 main components, including understanding the problem, developing a plan, carrying out planning, also check again. The data analysis methods used in the research carried out were qualitative descriptive methods. The subjects in this research were two students with high abilities, two students with medium abilities and two with low abilities at SMAN 3 Siak Hulu class XI. This research instrument is in the form of 2 questions about matrices. The results of this research also found that some students still did not carry out the four stages of problem-solving, so students' problem-solving abilities were still in the low category. Students were expected to continue learning and practicing to become more accustomed to solving problems with problem-solving abilities.
Keywords: Mathematical Problem Solving; Matrix; qualitative descriptive

Abstrak
Penelitian ini memiliki tujuan atau maksud untuk menganalisa kemampuan pemecahan masalah matematis siswa SMA pada materi matriks dengan menggunakan indikator yang terdiri dari 4 komponen utama antara lain: memahami masalah; menyusun rencana; melaksanakan perencanaan; juga memeriksa kembali. Dan metode analisis data yang digunakan pada penelitian yang dilakukan adalah menggunakan metode kualitatif deskriptif. Subjek dalam penelitian ini adalah 2 siswa berkemampuan tinggi, 2 siswa berkemampuan sedang dan 2 siswa berkemampuan rendah di SMAN 3 Siak Hulu kelas XI. Instrumen penelitian ini berupa 2 buah soal tentang matriks. Hasil yang ditemukan dalam Pada penelitian ini juga menemukan bahwa masih terdapat siswa yang tidak melaksanakan keempat tahapan pemecahan masalah sehingga kemampuan pemecahan masalah siswa masih tergolong kedalam kategori rendah, siswa diharapkan untuk terus belajar dan berlatih agar siswa lebih terbiasa dalam menyelesaikan soal kemampuan pemecahan masalah.
Kata kunci: Kemampuan pemecahan masalah matematis; matriks; kualitatif deskriptif

Introduction

In essence, education is a need for every human being. Without education, humans will find it challenging to develop and even be left behind (Novianti & Roesdiana, 2022; Marianti, 2023). Education is also an essential aspect of life so we can gain new, broader knowledge to face global challenges in the future (Rochadi & Yudhanegara, 2023). The role of education in schools contained in the curriculum focuses on developing human resources (HR), which include cognitive, affective, and psychomotor.

Mathematical has a mathematical meaning (Kusnadi & Mardiani, 2022; Robbani & Sumartini, 2023). According to Lestari et al. (2022), state mathematics is a science that plays a vital role in the development of IT and educational progress because mathematics can train a person's thinking skills, both critical and creative thinking. One of the many subjects that play the most crucial role in education is mathematics. Mathematics is a popular science because it is used in various fields (Suherlan et al., 2023).

Based on Fitriatien & Khotimah (2023), learning is interaction that is carried out well according to the components between students and teachers in the school environment from various sources. Mathematics learning is providing learning experiences to gain competence regarding the mathematical content being studied (Pratiwi et al., 2022; Saputra, Sofyan, & Mardiani, 2023). Mathematics lessons need to be taught and mastered starting from elementary school age (Pratiwi et al., 2022; Pitriyani & Afriansyah, 2023). The aim of learning mathematics is that students are able to understand the properties and concepts correctly in the simplification process, develop problem-solving skills, and develop mathematical abilities to obtain maximum learning results (Indriana & Maryati, 2021; Hasanah et al., 2023).

According to Istigosah & Noordyana (2022), also Novianti and Roesdiana (2022), problem-solving is a very important part of the mathematics curriculum. Problem solving ability is an important role in mathematics learning because almost every competency standard and basic competency is an aspect of problem solving ability (Suherlan et al., 2023). The importance of mastering problem solving by students is to develop themselves and also students to be able to solve mathematical problems that they encounter in everyday life (Midawati, 2022; Utami & Puspitasari, 2022).

Based on the results of analysis by the Program for International Student Assessment (PISA) and Trends in International Mathematics and Science (TIMSS), it is stated that the ability of Indonesian students to solve non-routine problems is still low, although Indonesian students are better at solving questions in the form of facts and procedural (Sriwahyuni & Maryati, 2022; Lestari et al., 2022; Rahmawati & Afriansyah, 2023). There was a lack of interest in learning, so learning felt boring, resulting in a low ability to solve mathematical problem-solving problems (Malik et al., 2022; Taufiq &

Basuki, 2022). The problems that students often experience when solving problems with problem-solving skills are a lack of skills in formulating a solution plan and a weak understanding of the problem (Sari et al., 2020; Lestari & Afriansyah, 2022). The tools were made only limited to the administrative requirements provided by the teacher without paying attention to the goals to be achieved (Atika et al., 2020; Sanidah & Sumartini, 2022). Teachers are often dull in teaching, never take the initiative to let students participate in learning, refuse to use learning models, memorize mathematical formulas, and do not understand the concepts for solving problems (Ratna & Yahya, 2022; Andini et al., 2023). This shows that the reality in the field is that students' mathematical problem-solving abilities are still low.

Considering that students' mathematical problem-solving abilities are still low (Kurniasari & Sritresna, 2022; Pratami, Sundayana, & Sofyan, 2023; Maryati, 2023), teachers must make efforts to improve them, namely, the learning process in line with the curriculum applied, paying attention to student characteristics, paying attention to learning objectives, providing opportunities for students to solve more complex contextual problems and also carry out learning applying the PBL model by giving issues to students (Santi et al., 2022; Yusup, 2023; Ramadoni & Admulya, 2023). Interest in learning has a significant role and has a big impact on students' attitudes and behavior when students who are interested in learning activities will be enthusiastic and try harder than less interested students (Malik et al., 2022; Mardarani & Apriyono, 2023).

The matrix concept is often used in everyday life, consciously or unconsciously. However, in reality, the results of matrix learning are not satisfactory. According to research conducted by Nuritasari (2017), student errors often include principle errors, operational errors, conceptual errors, 2% unintentional errors, 37.5% conceptual errors, 54.2% negligent errors, and increasing content editing errors. Conclusion 58.3% (Suherlan et al., 2023). Based on research Putra, Setiawan, et al. (2018), of 34 students, only 10 had a high understanding, with a percentage of 27.78%. It can be said that students' knowledge of solving a problem dramatically influences the process of solving a problem.

Method

The type of research that describes the analysis of students' mathematical problem-solving abilities on the mathematics matrix content of class XI high school students on matrix content is a descriptive research method that uses a qualitative descriptive approach. Qualitative research aims to describe and analyze phenomena, events, social activities, attitudes, beliefs, perceptions, and thoughts of a person individually or in groups (Isfayani, 2023). Descriptive research is research that presents an overview of something by describing it. This qualitative descriptive research aims to explain the

various learning difficulties experienced by students based on gender when learning mathematics on algebra content (Setyawati & Ratu, 2021).

This research was carried out at SMAN 3 Siak Hulu in May 2024, in the even semester of the 2023/2024 academic year. The research subjects were 6 students: 2 students with high abilities, 2 students with medium abilities, and 2 students with low abilities The class analyzed data and concluded the research results. Then, the assistance instrument uses a matrix content test, which contains two questions, created to determine students' mathematical problem-solving abilities in working on matrix content based on high, medium, and low ability, and then from 6 students, 3 are selected from the results of the written test using purposive sampling technique to interviewed. (Sugiyono, 2016) explains that purposive sampling is a technique for determining samples with specific considerations. The selection of subjects refers to the test results, 3 research subjects were selected, of which 1 student had high ability, 1 had medium ability, and 1 had low ability who could help researchers get the desired data and were willing to be interviewed. Researchers describe students' problem-solving abilities when completing tests from subject answers and interviews.

Indicators and sub-indicators of learning difficulties used by researchers (Nada et al., 2022) are as follows:

Table 1. Problem Solving Ability Indicators according to (Nada et al., 2022)

Question Indicator	Criteria for Knowledge Construction Activities
Understanding the Problem	Students are able to identify problems by showing what they know, asking questions, and completing the elements needed.
Make a Plan	Students are able to determine the formula or initial method for solving, and can carry out investigations to solve problems.
Implementing Planning	Students carry out the plan by completing the planned steps.
Check again	Students re-check the completion results to ensure that the work steps are in accordance with the procedure

The data analysis used is a qualitative data analysis procedure. Miles and Huberman in Sugiyono (2016) explain that data collection in qualitative research is interactive with data analysis. The data obtained is then analyzed by reducing the data, presenting the data, and drawing conclusions/verification. At the data reduction stage, the researcher selected initial data regarding student test results so that 4 students were selected. Next, the chosen subjects participated in interviews. All data obtained from test results and interviews will be analyzed and then presented completely and systematically in logical language. Next, conclusions will be drawn based on the data obtained and previous theories.

Result

The test questions used are as follows:

1) If the matrix value$P = \begin{pmatrix} 2 & x \\ 4 & 0 \end{pmatrix}, Q = \begin{pmatrix} -2 & -3 \\ 3 & 7 \end{pmatrix}$ dan det $PQ = 25$what is the value?x
2) Ani and Ina work in a shoe manufacturing factory. Ani can make 2 pairs of shoes every hour and Ina can make 3 pairs of shoes every hour. Ani and Ina work 5 hours a day, with 12 pairs of shoes made. If the number of hours worked by both is not the same. Determine:
   a) Form a linear equation for two variables in this problem
   b) Form a matrix of the situation and its solution
   c) Ani and Ina's working hours in a day

Description of Research Results on Students' Problem-Solving Abilities on Matrix Content

After 6 students were selected, the students were then given math test questions on matrix content. The test questions consist of 2 questions in the form of descriptions which a mathematics lecturer has validated. The test results are used to analyze problem-solving abilities in high school students' matrix content. Next, representatives of 1 high-ability student, 1 medium-ability student and 1 low-ability student were selected to be interviewed. The following is a description of problem-solving abilities in high school students' matrix content through the results of student work and interviews:

1) Problem Solving Ability in High Ability Students

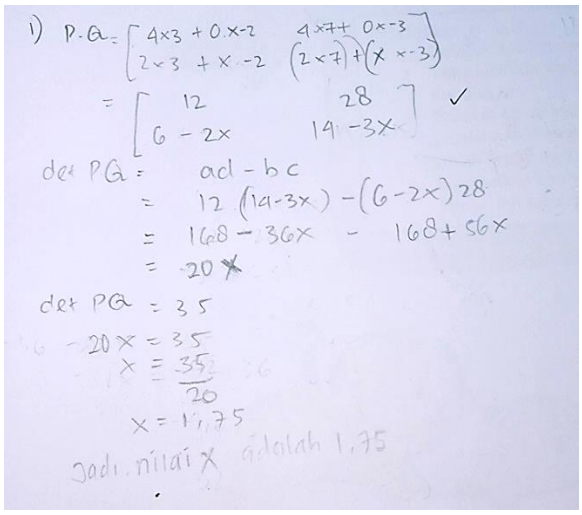

Figure 1a. ZF student's answer number 1

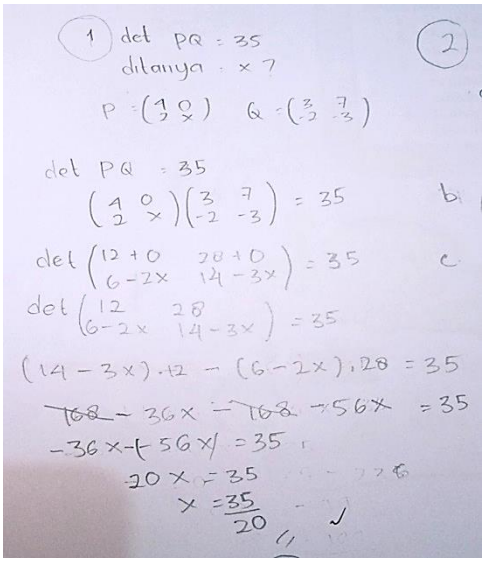

Figure 2b. CDG student's answer number 1

From answer number 1, see Figure 2a and 2b, both students can show that these students are students with high abilities. When working on the first stage of problem solving questions, namely understanding the problem, high-ability students, ZF, were not yet able to reach the indicator of understanding the problem, where they did not write down what was known and asked in the question, while CDG students were already

capable in the first indicator by writing down what was known and asked in the question. Furthermore, in the second indicator, namely preparing a solution plan, both students were able to make examples and make formulas. The next stage is the indicator of implementing planning. These two high-ability students were able to write problem-solving strategies using specified mathematical models and formulas.At the final stage of the re-checking indicator, ZF students had made complete conclusions and re-checked their solutions, while CDG students had not maximized the re-checking indicator, in which case the students did not write complete conclusions from the answers obtained.

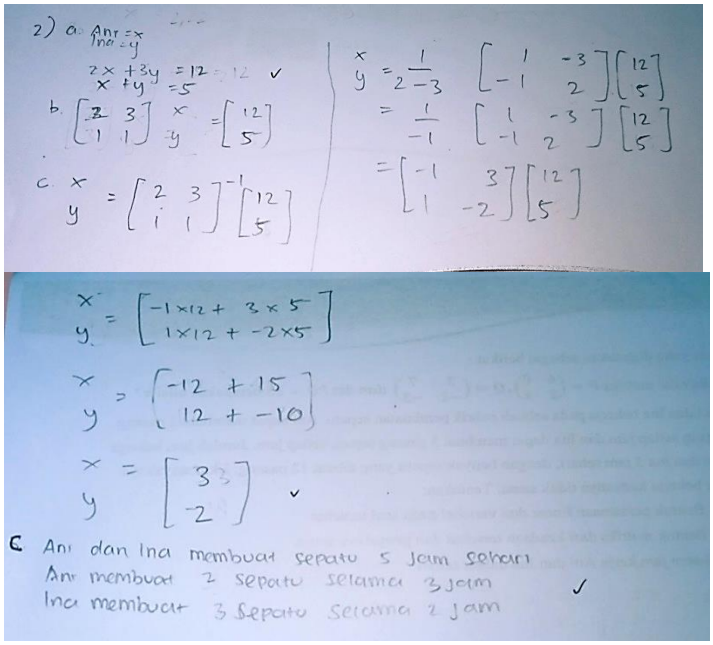

Figure 3. Answer number 2 is ZF student

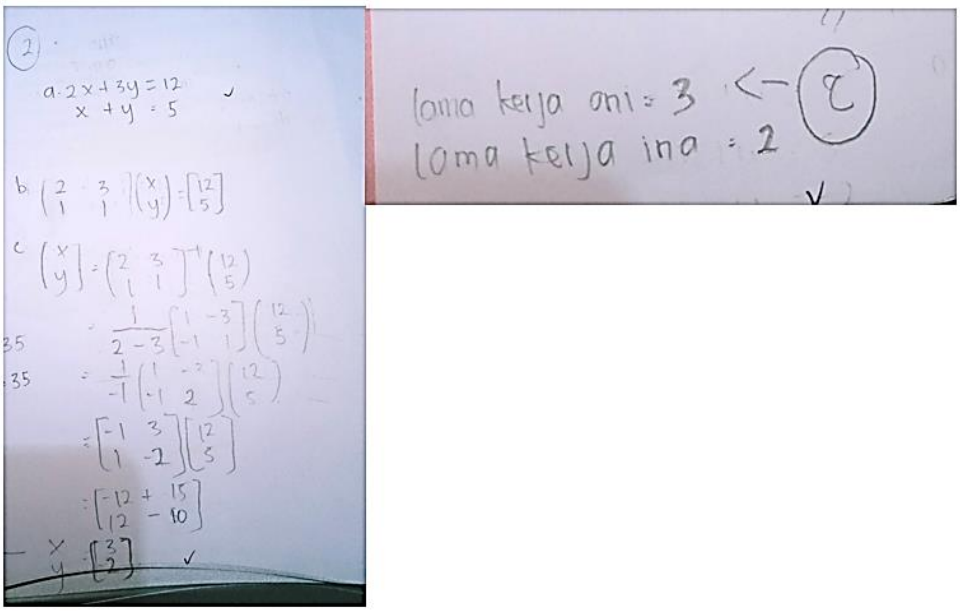

Figure 4. Answer to question number 2 CDG students

From answer number 2, see Figure 3 and 4, both students can show that these students are students with high abilities. Furthermore, when working on problem solving questions at the initial stage, namely problem planning, these high-ability students were not able to reach the indicator of understanding the problem optimally, where in the indicator of understanding the problem there were two indicators of ability, namely knowing and asking about the problem, but the student only wrote down what he knew. However, the student was able to achieve the indicator of planning a solution, where in this indicator there are two indicators of ability, namely making examples and making formulas. It can be seen from the answer that the students were able to put known variables into mathematical form correctly, but CDG students did not write the examples.$x$are Ani and$y$is Ina, then students are able to create a formula in the form of a linear equation for two variables, so that the equation becomes $2x+ 3y= 12$ for the number of shoes Yuni and Rika produce in a day and$x+y= 5$ for the duration of Yuni and Rika's working time in a day. Furthermore, it can also be seen that the student is able to achieve the indicators of carrying out the plan, where in the indicators of carrying out the plan there are several indicators of ability, including being able to choose the formula correctly, working according to the steps, calculating correctly, and writing answers correctly. Furthermore, ZF students have carried out the last indicator, namely re-checking, where ZF has made a complete conclusion, while CGD students have not yet maximized the indicator of understanding the problem, these students have also not maximized the re-checking indicator, where in this indicator the student has not written a complete conclusion. from the answers obtained.

Below is a transcript of the interview results regarding the work of ZF students:

P : Do you understand the meaning of question number 1 or number 2?
ZF : Understand, sis.
P : From question number 1 or number 2, what information did you get?
ZF : Knowing the unknown value in the matrix and finding the X and Y values through the inverse matrix
P : Furthermore, from the information obtained, what is the meaning of question number 1 or number 2?
ZF : Look for the X value in the matrix and find out how many hours Ani and Ina work
P : In your opinion, what are the steps for working on question number 1 or number 2?
ZF : Multiply matrices P and Q. Next, look for det P and Q and analyze the problem, write the matrix arrangement, then solve with the inverse so that you get X and Y.
P : So what do you do next to find out what the x value is?
ZF : Mwrite the equation of det P and Q so that you can value X and for number 2 with the inverse formula for the matrix
P : After you have prepared a plan for the questions above, what is the next step?
ZF : MMultiply matrices P and Q and look for the determinant then get the result 1.75 and for number 2 solve with the inverse formula, after that get ani 3 hours and an ina 2 hours
P : Can you do it yourself without looking at examples or asking friends?
ZF : Yes, sis
P : After finding the answer, what steps do you take next?

ZF : Check it again before collecting it to your sister.
P : Do you re-check the results of your work?
ZF : Ya sis

1) Problem Solving Ability in Students with Medium Ability

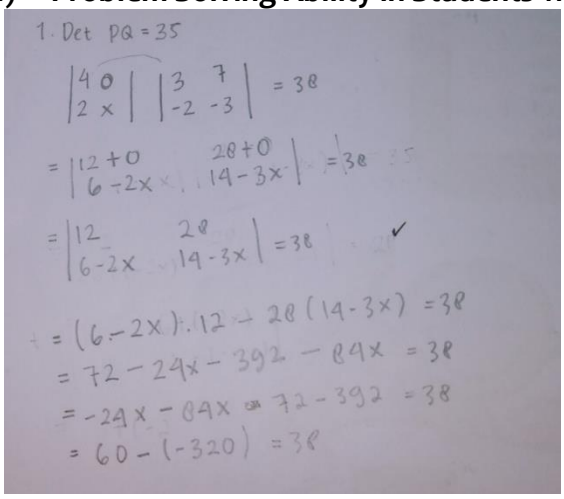

Figure 5. Answer to question number 1 CR students

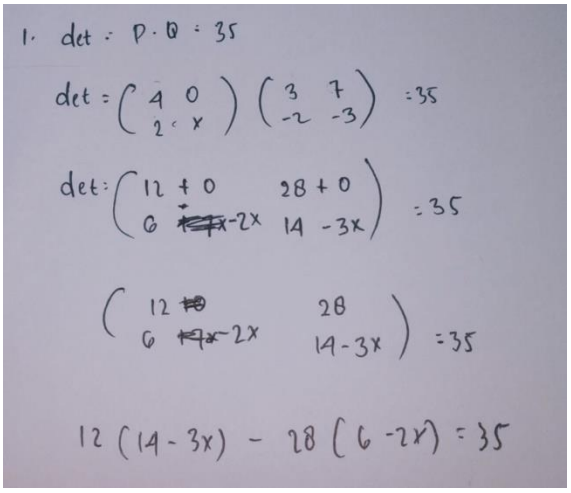

Figure 6. Answer to question number 1 EM students

From answer number 1, see Figure 5 and 6, both students can show that these students are students with moderate abilities. When working on the first stage of problem solving, namely the indicator of understanding the problem, the two students were not able to understand the problem, such as writing down what they knew. The next stage was preparing a plan, the two students had written down the formula that would be used in solving number 1. In the carrying out the plan stage, the two students were unable to complete it to completion so they did not answer the problem solving question correctly. And at the final stage of checking again, students were also unable to draw appropriate conclusions because they did not answer until the end.

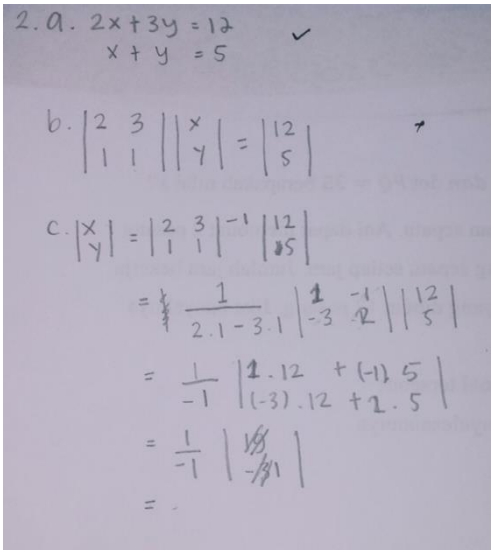

Figure 7. Answer number 2 CR students

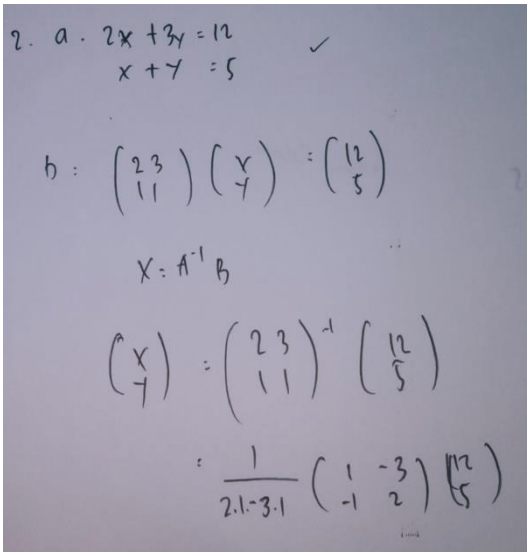

Figure 8. Answer number 2 EM students

From answer number 2, see Figure 7 and 8, both students can show that these students are students with moderate abilities. When working on problem solving questions at the initial stage with indicators of understanding the second problem, students are not yet able to write down what they know in the problem. The next stage is to prepare a plan, both students are able to write down the variables for example and write the formula used to solve the problem. Next, in the stage of implementing the plan, the two students had started to solve the problem but did not finish it so that in the final stage of checking again, the two students were unable to draw conclusions because they did not complete the problem solving question until the end. Below is a transcript of the interview results regarding the results of EM students' work:

P : Do you understand the meaning of question no1 or number 2?
EM : That's quite understandable, sis.
P : From question number 1 or number 2, this is informationwhat did you get?
EM : For question number 1 the values of P and Q, det PQ = 35 and for question number 2 ani can make 2 pairs of shoes and ina can make 3 pairs of shoes.
P : Furthermore, based on the information obtained, what is the meaning of question number 1 or number 2?
EM : Question number 1 asks for the value of
P : In your opinion, what are the steps for working on question no. 1 or noThese 2?
EM : LThe steps to solve problem number 2 are to create an equation and solve it using the inverse formula
P : After you have prepared a plan for the questions above,what's the next step?
EM : Question number 1 looks for the determinant and question number 2 creates an equation$2x + 3y = 12$, after that search using inverse with results$x + y = 5\frac{3}{2}$
P : Can you do it yourself without looking at examples or asking friends?
EM : SI can't do it, bro
P : After finding the answer, stepwhat do you do next?
EM : Double-check whether the steps and answers are correct or not.
P : Do you re-check the results of your work?
EM : Ya I did it sis

2) Problem Solving Ability in Low Ability Students

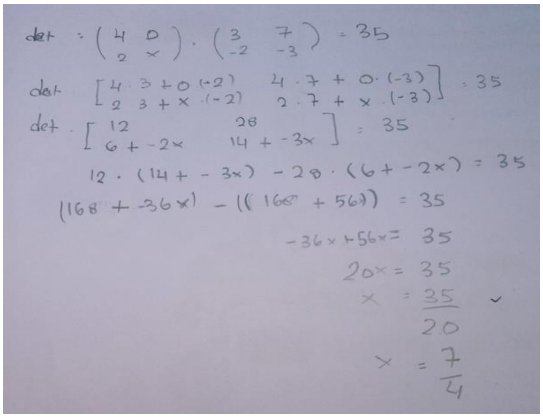

Figure 9. Answer number 1 student YS

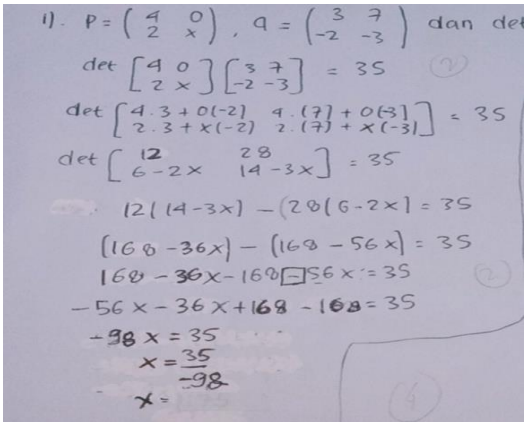

Figure 10. Answer number 1 ERS students

From answer number 1, see Figure 9 and 10, both students can show that this student is a student with low ability. When students worked on the first stage of problem solving questions with the indicator of understanding the problem, the two students did not yet understand how to achieve this indicator because the YS students did not write down what they knew and were asked about the problem and the ERS students only wrote down what they knew. The next stage is the indicator of preparing a plan. At this stage the two students were also unable to write down the solution strategy and did not write down the formula used in the problem. The next stage was carrying out planning, at this stage both students did not answer correctly and some did not write their answers at the end because they had not planned correctly at the beginning. The final stage is checking again, at this stage the two students cannot make conclusions and do not check again what they have made.

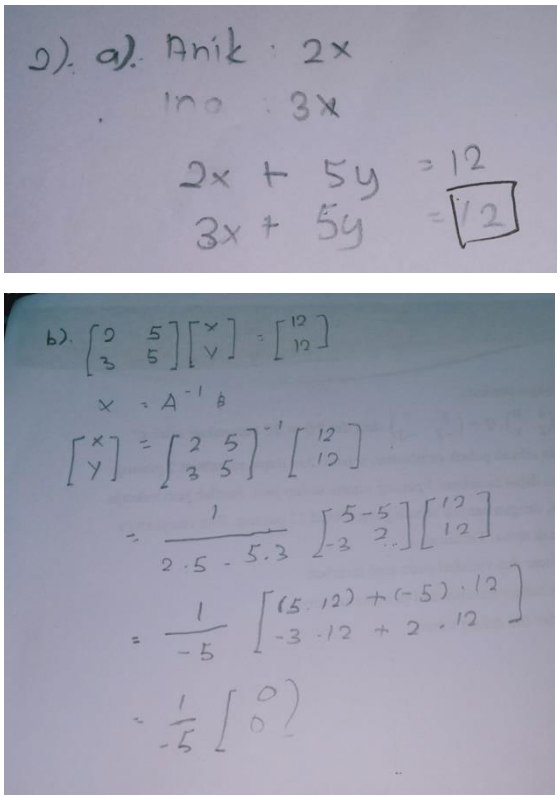

Figure 11. YS student's answer to number 2

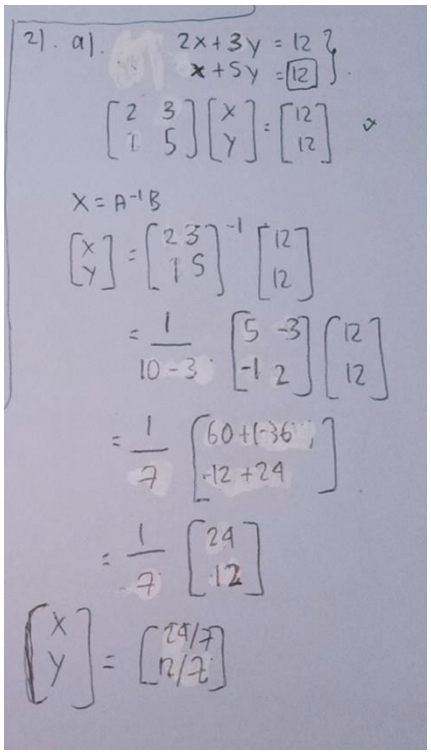

Figure 12. ERS student's answer number 2

From answer number 2, see Figure 11 and 12, both students can show that these students are students with low abilities. When working on the first stage of problem solving questions, namely the indicator of understanding the problem, at this stage students are not able to achieve this indicator optimally, where students do not write down what they know and are asked about the question. The next stage is preparing a plan, at this stage students can write down the formula used but writing the example is not correct. The third stage is carrying out planning, at this stage the two students were

unable to answer correctly because they were not correct at the planning stage so the results obtained were wrong. In the final stage, the two students did not make conclusions from the answers obtained.

The following describes the transcript of the interview results regarding the work of YS students:

P : Do you understand the meaning of question no1 or number 2?
YS : Quite understanding sis.
P : From question number 1 or number 2, this is informationwhat did you get?
YS : How to find numbers x and y in a matrix
P : Furthermore, from the information obtained, what is the meaning of question number 1 or number 2?
YS : Determine the x and y values of the matrix
P : In your opinion, what are the steps for working on question no. 1 or noThese 2?
YS : Step by step formula for moving segments
P : SoWhat do you do next to find out what the x value is?
YS : Move the value so that you get the x value from the moving result.
P : After you have prepared a plan for the questions above,what's the next step?
YS : Do the questions carefully
P : Can you do it yourself without looking at examples or asking friends?
YS : I can't do it, bro
P : After finding the answer, stepwhat do you do next?
YS : Collect the questions given.
P : Do you re-check the results of your work?
YS : TOf course I'll check again, sis

Discussion

1) Problem Solving Ability in High Ability Students

Highly skilled students can write mathematical models and understand what steps must be taken to solve the problem. This is in line with research (Aspiandi et al., 2020) which states that students with good problem solving abilities can find the right strategy or solution to solve the problem. At the stage of carrying out the solution plan, students with high abilities can already write problem solving strategies according to the mathematical model that has been determined and have carried out calculation operations correctly and appropriately. This is in line with research (Aspiandi et al., 2020) which states that students who are able to solve problems on questions and get the final answer correctly means that the student has carried out arithmetic operations and used problem solving skills. At the final stage, CDG students cannot carry out re-examination by writing conclusions on what has been obtained in the calculations. This is in line with research (Akbar et al., 2017) which stated that students did not carry out the re-examination stage because they were sure they had provided the correct solution results. But for ZF students, they have checked their answers again.

2) Problem Solving Ability in Students with Medium Ability

Students with moderate abilities are able to understand problems and develop plans for solving problems. However, when carrying out planning, students with moderate abilities did not complete it to the end because they did not understand the operations of addition, subtraction and multiplication so that these students did not finish until the end. This is in line with research (Parulian et al., 2019) which states that the reason students have difficulty in carrying out the stages of planning problem solving is because students are not able to transform problems into mathematical models carefully. Then at the final stage, students do not draw conclusions about the solutions they have obtained. This is in line with research (Akbar et al., 2017) which stated that students did not carry out the re-examination stage because they were sure they had provided the correct solution results.

3) Problem Solving Ability in Low Ability Students

Low ability students experience errors in understanding the problem and making plans for the questions given. At the stage of implementing the solution plan, students do not know the correct strategy and are confused about addition, subtraction and multiplication operations so that the results obtained are incorrect. This is in line with research (Parulian et al., 2019) which states that the reason students have difficulty in carrying out the stages of planning problem solving is because students are not able to transform problems into mathematical models carefully. If the problem solving indicators are not met then at the re-examination stage students with low problem solving abilities will not be able to draw conclusions well. This is in line with research (Akbar et al., 2017) which stated that students did not carry out the re-examination stage because they were sure they had provided the correct solution results.

Conclusion

The results found in this research also found that there were still students who did not carry out the four stages of problem solving so that students' problem-solving abilities were still in the low category. Students were expected to continue learning and practicing so that students were more accustomed to solving problems with problem solving abilities. Therefore, further research is needed on student problem solving to produce additional data that can be used as assessment and analysis content to create learning models that can improve learning outcomes, especially those related to students' mathematical problem-solving abilities. Research is also needed that focuses on students working on mathematical problem-solving abilities with the aim of producing data that can be used as assessment and analysis content to create learning models for students' mathematical problem-solving abilities that can be improved.

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Conflict of Interest

The authors declare that no conflict of interest regarding the publication of this manuscript. In addition, the 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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