

STUDENTS' ERRORS IN PROBLEM-SOLVING REVIEWED FROM THE PERSPECTIVE OF MATH RESILIENCE

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ABSTRACT

The purpose of this research is to: 1) identify students' mistakes in solving mathematical problems in trigonometry in terms of mathematical resilience according to the Newman Procedure, and 2) discuss trigonometric problems from the point of view of mathematical resilience according to the Newman Procedure. This type of research is qualitative. The research subjects were 3 students from SMA Negeri 1 Slawi, selected using a purposive sampling technique. The methods of data collection are tests, questionnaires, interviews, and documentation. The data analysis techniques used are data reduction, data presentation, and drawing conclusions. Based on the results of the data analysis, we obtained the following: (1) Students' mistakes in reading the questions include: students do not understand the context of the sentence, students do not correctly understand the meaning, and students do not read all the meanings of the desired words. (2) The answers to the questions include: answers that do not contradict the accepted answers but do not coincide with the inquiry accepted in the question, and answers that do not address what is required in the problem posed, often being a question of application. (3) Transforming the problem includes: considering a method being investigated, using the wrong method, and not translating the method to be used. (4) Process skills contain: concept errors, errors in computing, not continuing the settlement procedure, and not processing calculations. (5) The final answer includes: an answer that fits the context of the question, and an answer that does not match the conclusion. The contributing factors include: lack of self-confidence, confusion in describing the problem in the form of a picture, hurrying in solving problems, lack of accuracy, inability to manage time well, inability to think about problems thoroughly, forgetting to identify what is suitable and trying, confusion in determining the formula to be used, and solving the problem without completing the conclusion.

Keywords: students' errors, problem-solving, Newman procedure, math resilience, trigonometry

INTRODUCTION

The low mathematical ability of Indonesian students is evident from the results of TIMSS (The Third International Mathematics and Science Study) (Martin & Mullis, 2019).

According to international research, the average mathematics performance of Indonesian students is still far below the international average. Indonesia ranked 46th out of 51 countries with a score of 397 in 2015 (Lastiningsih, 2017; Watts, 2015). In the 2009 Program for International Student Assessment (PISA), the average scores in reading, mathematics, science and technology were 397, 386 and 403 respectively, still below the average score of half the world to 500 (Chu, 2016; Schleicher, 2019, 2023; Stacey & Turner, 2015). This means that the level of mathematical ability in Indonesia is low.

One of the mathematical ability students need to learn in math is problem solving. (Afifah Nur Qomariyah, Isnani, 2018; Widodo, 2018b; Widodo & Turmudi, 2017). Basically, mathematical problem solving is one of the important aspects of mathematics that students acquire and develop while learning mathematics (Afifah Nur Qomariyah, Isnani, 2018). Problem solving is the personal process or trying to fight or overcome problems or problems when the answer or how to respond is unclear (Jonassen, 2011; Zulfaa Mulyani, Wikan Budi Utami, 2021). Students solve problems in two stages: mathematical interpretation and calculation process. Newman also posits that verbal and mathematical skills support mathematical problem solving (Granberg, 2016; M. Rohmah, 2018; Singh et al., 2010).

The low problem solving ability of students can be seen from the number of students who make mistakes while solving problems. (Widodo, 2019; Widodo et al., 2020; Widodo & Turmudi, 2017). In addition, these student mistakes also become one of the instructions to find out the extent of mastery of student material. In accordance with the results of previous studies which stated that many students have difficulty in the level of error II and III of Newman error analysis, namely errors of understanding and transformation (Zakaria et al., 2010; Pungut & Shahrill, 2014; Singh et al., 2010). Errors in solving mathematical problems often occur either in writing or verbally. During the process of teaching and learning mathematics, students will face many obstacles because problem-solving in mathematics is a very complex skill. Sometimes students know how to answer questions, but are careless in calculations (Lai, n.d.; Oktaviani, 2019; Widodo, 2019).

This study will use the Newman procedure Analysis Stages developed by Anne Newman in 1977, which is a tool that can help teachers to find out students' problem-solving errors. Newman Procedure is the stage for understanding and analyzing how students solve a problem. Newman Procedure is suitable to identify students' mathematical errors and classify these types of errors based on the level of students' problem-solving abilities (Oktaviani, 2019). By identifying mistakes made by students in solving problem-solving problems and providing alternative solutions to these problems, similar errors can be minimized so that the results of learning mathematics and students' problem-solving abilities can be improved. Newman Procedure is a tool used to find out students' problem-solving errors. When students try to answer a problem, then the student has passed a series of obstacles in the form of stages in solving problems, including reading, understanding, transformation, processing skills and writing or encoding (Prakitipong & Nakamura, 2006; Raduan, 2010; M. Rohmah & Sutiarso, 2018; Saleh et al., 2017).

One material that is considered important in helping develop problem-solving is trigonometry material. Mastery of basic trigonometric abilities requires good mathematical problem-solving skills. Student at SMA Negeri 1 Slawi, central java need to improve their trigonometric problem-solving abilities to solve existing problems. This was proven during an interview with students that all students interviewed said that the material most disliked because of difficulties was trigonometry.

Of course, a person's ability to solve problems varies. This is due to differences in the characteristics of each individual, so they need to be accommodated in learning to achieve the best results (Sari & Valentino, 2016; Veloo et al., 2017). Psychology, with its various branches, has identified many variables that reflect individual differences and influence the learning process, such as intelligence, intelligence, thinking style, thinking style, assumption strength, resilience, and initial ability. All these factors should be the best interest of teachers when planning and implementing teaching and learning activities. One thing that teachers should pay attention to is students' math resilience, where students' math resilience is students' ability to face a challenge or problem. To overcome fear, fear of challenges and difficulties, requires hard work and good language skills, students must have a decisive and strong character that has mathematical resilience.

The thinking process of each student is different in solving mathematical problems. Their responses also differ, some give up, and try and some never give up. One of the factors that influence it is mathematical resilience (Centre & Technology, n.d.; Duah, 2017; Goodall & Johnston-wilder, 2015; Gü, 2018), which is the process by which a person is able to achieve success or success by adapting despite being in a situation full of challenges that are high risk and in a frightening atmosphere. Therefore, this study aims to analyze the errors of students at Senior High School in Slawi in problem-solving in terms of mathematical resilience on trigonometry material.

LITERATURE REVIEW

Mathematical Problem-Solving

Mathematics is a complex problem solving activity and not just thinking in a linear manner (Szabo et al., 2020). Mathematical problem solving is basically a reasoning process, not just rote memorization. Problem solving expects students to develop an understanding and explain the process used to solve a problem and not just remember and apply procedures.

Mathematical problem solving involves understanding the problem, formulating a solution plan, executing the plan, and evaluating whether the solution is successful or not (follow-up). Mathematical problem solving refers to the cognitive processes used to solve mathematical problems (Kukulska-hulme et al., 2017). Research (Öztürk et al., 2020) explains that Mathematics problem solving skills are influenced by students' abilities in reading comprehension, perceived self-efficacy towards Mathematics, and attitudes towards Mathematics. Research (Pambudi et al., 2020) explains that to have problem-solving abilities,

mathematical connection abilities are needed which contain the ability to provide mathematical ideas, in the form of facts/data, concepts, principles, representations and mathematical procedures (Öztürk et al., 2020). Research (Granberg, 2016) explains that to gain problem-solving abilities, you need to struggle to change yourself to be more productive, so that you can reconstruct knowledge that is useful for forming new knowledge. So mathematical problem solving is a process or effort that originates from a person/student to solve a problem by involving conceptual understanding, computational skills, the ability to find solutions, explore patterns, and formulate hypotheses in solving a mathematical problem.

To solve mathematical problems, a method or systematic steps are needed so that the solving process becomes easy and focused. One way to do this is to use the method introduced by Polya (Widodo, 2018a), namely the stage of understanding the problem, the stage of making a plan, the stage of implementing the plan, and the stage of looking back at solutions that have been completed. Problem solving indicators according to Polya (1973) in Siswono, Tatag Y.E. (2018) and Newman's model for analyzing student errors in solving mathematical problem solving problems. By knowing the students' mistakes, it can be used as an indicator to find out how far the students' understanding and problem solving abilities are regarding trigonometry material.

Newman Procedure

Mathematics is a challenging subject because students are encouraged to solve problems carefully (Saleh et al., 2017). In dealing with problems, students need the ability to identify and understand the problems they face, including problems that are similar in solving the problem. Students often make mistakes in solving mathematical problems. To see the type of error that occurred, it needs to be analyzed using the Newman procedure. The Newman procedure can see the mistakes made by students in solving analogy questions so that it provides an idea for teachers to develop learning that involves analogy questions as assignments/exercises and tests (Saleh et al., 2017).

To find out the types of errors and the causes of the errors made, it is necessary to do a more in-depth analysis of each error made by students. The error analysis used is Newman error analysis. The Newman error analysis method was first introduced in 1977 by a mathematics teacher in Australia named Anne Newman. The Newman procedure makes it easier for us to analyze errors because it has five stages that students must go through when solving problems. The five stages are the reading stage, understanding stage, transformation stage, process skills stage, and coding stage (Tayeb et al., 2018). Based on research (Alhara et al., 2021; Anggraini et al., 2022; Thomas & Mahmud, 2021) that with Newman analysis teachers are helped in mapping students' difficulties in problem solving so that teachers can provide solutions, one of which is by developing innovative learning. So it is important for teachers to carry out the Newman procedure to find out students' difficulties so that teachers

can develop learning that is appropriate to students' needs, so that students have mathematical problem solving abilities.

(Dirgantoro et al., 2019; Halim & Rasidah, 2019) provide several factors and indicators that cause students to make mistakes in solving essay questions based on the Newman procedure as shown in Table 1 below.

Stages of Newman's Analysis	Indicator
<i>Reading</i>	Students cannot read the sentences in the questions correctly, that is, they do not understand the terms, words, sentences and symbols in the questions through accurate interpretation of the language. This can be seen in the students' lack of clarity in writing down the information from the questions.
<i>Comprehension</i>	Students can read the questions well but cannot fully understand the question in question, including: not being able to determine what is known and what is being asked, not being able to state what is being asked correctly and using their own language.
<i>Transformation</i>	Students do not have a relevant problem solving plan to solve problems correctly, and students cannot transform sentences into mathematical form. For example: wrong or unable to determine the mathematical model and choosing the wrong solution model.
<i>Process Skill</i>	Students cannot solve problems according to the problem solving steps that have been planned at the transformation stage correctly or students cannot complete arithmetic operations correctly.
<i>Encoding</i>	Students cannot check and provide conclusions on the results of problem solving, for example: students cannot determine the final answer and cannot determine conclusions.

Mathematical Resilience

(Nababan et al., 2021) explain that resilience is related to students' affective abilities in dealing with obstacles and negative conditions encountered during learning. Research (Harsela & Asih, 2020) explains that mathematical resilience can be used to predict students' academic abilities. (Afriyanti, Mulyono, et al., 2018) explains that mathematical resilience contributes to mathematical literacy skills. Indicators of Mathematics Resilience (Harsela & Asih, 2020) are as follows: 1) learning mathematics is valuable, meaningful and useful; 2) learning from mistakes, giving positive responses, and being resistant to giving up in negative situations or difficulties when learning mathematics; 3) have a strong desire, perseverance, try hard to continue to struggle in facing challenges or difficult situations; 4) persistent,

diligent, and confident in your own abilities, understanding, and experience to study mathematics. From these indicators, it can be seen that differences in students' mathematical resilience levels will influence their ability to solve mathematical problems (Afriyanti, Wardono, et al., 2018; Arjun & Muntazhimah, 2023; Kurnia et al., 2018). This is also in accordance with research (Fitriani et al., 2023; S. Rohmah et al., 2020) that positive mathematical resilience during the learning process can improve students' ability to solve mathematical problems. So that mathematical resilience is a student's affective ability to face problems such as overcoming anxiety, fear in facing challenges and difficulties faced in learning mathematics so that hard work and good language skills, a persistent attitude and resilience are required from students.

RESEARCH METHODOLOGY

The research method used is a qualitative research method. This research method aims to show more carefully the students' mistakes in solving trigonometric material problem descriptions with Newman's procedure guide. The design in this qualitative research method departs from potential, curiosity in what objects are there and from temporary problems. This problem developed after researchers entered the field. After exploring, new researchers can find the focus of research. Based on the focus of the research, the researcher can then formulate the problem. Based on the focus and formulation of the problem, the qualitative researchers then collected data.

The research procedure is the stage or step of the researcher in carrying out his research. The stages in this research are the stages of preparation, the stages of work at school, and the stages of data analysis. Sources of data in this study can be divided into two, namely primary data and secondary data. Primary data sources in this study are data on the results of tests of problem-solving abilities, data on the results of mathematical resilience questionnaires, and interview data in the form of scripts. Secondary data in this study is the document daily test scores of students in semester 1 mathematics subjects class X.9. The form of data in this study is the list of names of class X.9 students of Senior High School at Slawi, test questions describing problem-solving abilities, student answer sheets, mathematical resilience questionnaires, interview guidelines, and scripts from the results of voice recordings during interviews. In addition, there are also photographs and some additional documents needed for research. The place of research is in Senior High School at Slawi, the perpetrators are grade X.9 students of Senior High School at Slawi and the activity is learning activities in class X.9 of Senior High School at Slawi. Sampling in this study using a purposive sampling technique. Purposive sampling is a data source sampling technique with certain considerations. Data identification in this qualitative research, one class was chosen, namely class X.9 of Senior High School at Slawi. Students in the class are categorized based on mathematical resilience using a mathematical resilience questionnaire. Students in this class have low mathematical solving ability indicated by the results of daily tests whose grades are below 75. The determination of the subjects in this study was carried out based on the results

of a mathematical resilience questionnaire. Subjects were selected by looking at the results of the questionnaire. The category of mathematical resilience level in this study uses high, medium, and low resilience. Three male students as research subjects in this study, taken with regard to teacher considerations relating to the subject's ability to express opinions or ways of thinking verbally and in writing. It aims to obtain subjects who can support the implementation of research.

Data collected through a mathematical resilience questionnaire consisting of 6 indicators, namely showing perseverance, confidence/confidence, working hard and not easily giving up facing problems, failures, and uncertainties; showing the desire to socialize, easy to provide assistance, discuss with peers, and adapt to their environment; bring up new ideas/ways and look for creative solutions to challenges; use the experience of failure to build self-motivation; have a curiosity, reflect, research, and utilize various sources; have the ability to control themselves, aware of their feelings are used to determine the subject of research. Three male students of class X.9 of Senior High School at Slawi as research subjects were conducted based on purposive sampling techniques.

RESULT AND DISCUSSION

Based on the evaluation of the scores of eight male students, the mathematical resilience is low, medium and high, and the results of the research on mathematical elasticity with mathematical problem solving problems are based on the results. Each study analyzed the mathematical resilience question, which is the result of the performance test, and then added the analysis of the results by triangulation based on the interview.

Three male students as research subjects taken in this study have conducted a mathematical problem-solving ability test that contains 1 item description questions, then analyzed how students' mistakes in solving mathematical problem-solving problems in terms of mathematical resilience. Data collection was also carried out by means of in-depth interviews. The results of the analysis were coded using research subject code (S1, S2, S3), while the problem-solving problem was written problem 1 (M1).

Analysis of students' problem-solving errors is based on the Newman Procedure which has 5 stages to be analyzed, namely: (1) reading the problem (reading), (2) understanding the problem (comprehension), (3) transforming the problem (transformation), (4) skills process (process skills), and (5) writing answers (encoding). Description of student errors in solving problems is based on the results of tests of problem-solving abilities and interviews with the subject. Problem-solving indicators used are: (1) understanding the problem, (2) making a solution to the plan, (3) completing the plan of the resolution, and (4) checking back. The following is a description of students' mistakes in solving problems in terms of students' mathematical resilience (Ekayanti & Nasyiithoh, 2018; Veloo et al., 2017; Veloo & Krishnasamy, 2015; Wijaya et al., 2014).

3.1 Subjects with Low Resilience

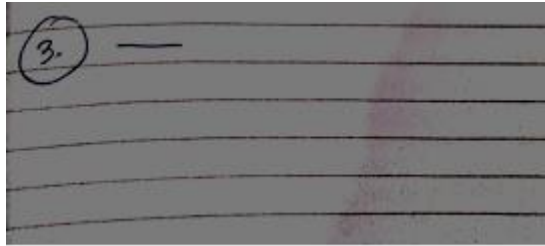


Figure 1. Written Test Results of S1 on M1

Based on Figure 1 it can be found that S1 cannot solve the story problem. S1 is said to be unable to go through the stages of reading questions, understanding questions, transformation, process skills, and writing final answers (Gü, 2018; Haghverdi, n.d.; Kristayulita & Nusantara, 2018; Peatfield & Academy, 2015).

R: "Next, question number 3. Try reading out question number 3 then what is known and asked about question number 3? "

S: "Mrs. Tania has a garden. What is known is the length of the base of the park AB is 7 m, and the length of the sloping side of the park AD is 6 m, while the length of one diagonal of the park is BD is 8 m. Who was asked to determine the cosine value of the angle formed between the length of the side of the base of the park AB? " (While illustrating the problem in the form of a picture)

R: "All that's known is that?"

S: "Yes, Ma'am."

R: "Sure? Now if the parallelogram park is not known, right? "

S: "I see ... So the park in the form of parallelogram is well known, Ma'am, I think the only known is in the form of numbers, ma'am." (While illustrating the problem in the form of a picture)

R: "Yes. Then for question number 3 why don't you finish? "

S: "The first is because I solved problem number 1 it took a long time to rationalize it, but still I did not find the right results. Then I am still confused about the characteristics of when I use the formula of the sine and cosine rules. "

R: "Next, did you double check the answers before they were collected?"

S: "No, because the time is up, so I just collected it, Mom."

R: The last question is, why did an error occur in writing the answer?"

S: "Because there is still a lack of understanding of how to describe and from these images what formulas should be used according to the drawings."

R: "Okay, thank you for the time and information given. Please resume activities again. "

S: "Yes ma'am, you're welcome."

Based on the results of interviews, it is known that in question M1, S1 can illustrate the story problem in the form of pictures. In interviews, S1 can explain what is known and what is asked on the M1 problem, but it is still incomplete. When S1 was asked to explain the

method used along with the process, S1 was confused and it was still wrong when to use the sine and cosine formula. S1 on the M1 problem does not provide a conclusion.

Error S1 falls into the category of transformation error, process skills, and writing the final answer. Test and interview results are comparable to the results of resilience on S1 which shows the criteria for low mathematical resilience with 1 indicator achievement, namely indicator 5.

3.2 Subjects with Medium Resilience

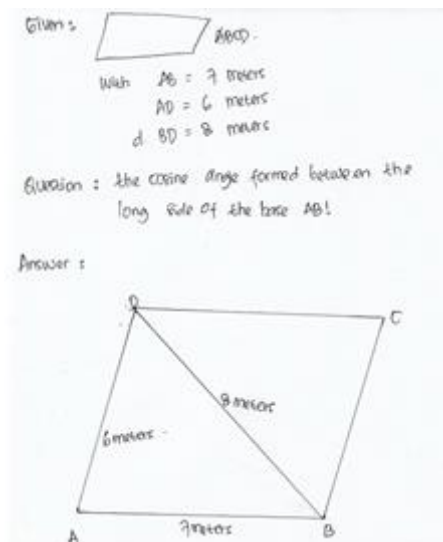


Figure 2. Written Test Results of S2 on M1

Based on Figure 2, it can be found that S2 can solve story problems by going through 2 stages, namely the stage of reading questions and understanding questions. However, S8 cannot solve the questions at the transformation stage, process skills, and writing the final answers.

P: "Try reading to question number 1 later what is known and asked about question number 1?"

S: "The problem is that Mrs. Tania has a jajarganjang-shaped garden. It is known that the length of the base of the park AB is 7 m, and the long side of the sloping park AD is 6 m, while the length of one of the diagonal gardens, BD , is 8 m. Determine the cosine value of the angle formed between the long sides of the AB pedestal. What is known is the length of AB 7 m, and the length of AD 6 m, and the diagonal length of BD 8 m. What is being asked is the long side AB ." (While illustrating the problem in the form of a picture)

P: "Now, for what is known is still lacking. Then what is being asked about this problem is you are still wrong. Try to consider what is right?"

S: "Oh yeah, ma'am, in my opinion, if it's obtained I don't know what else. And for the one being asked, it's really the cosine value of the angle that forms between the dear sides of the AB park."

P: "Well, for those who are really being asked, why on your answer sheet is it wrong what was asked from number 1? And to know it needs to be added in the form of jajarganjang park. "

S: "Oh yes ma'am, on the answer sheet I answered wrongly what was asked from number 1, because I was too much in a hurry to not see any cosine writing value and it has increased very quickly, ma'am."

P: "Okay, then in terms of pictures. In problem number 1 you have really thought about it, but there are no more units. Why don't you think of the unit in the picture? "

S: "Because when I finished I hastily forgot to forget the unit in the picture."

P: "Well, do you continue at number 1 to finish this method and finish the conclusion?"

S: "When I will change the way to finish and conclude my answer sheet has been drawn by my friend, tell me to collect it, ma'am."

P: "I see. Furthermore, have you answered back before being collected?"

S: "I will not check again ma'am, because my answer sheet has been pulled by my friend so I cannot check my answer again mom."

P: "The last question, bro, how could it be wrong to answer, both from question number 1?"

S: "I was wrong in answering most of the units because at the moment I think above is just a little and I finish it in a hurry, others are done I'm not done yet, so I'm not very complete, ma'am."

P: "Okay, thank you for the time and information given. Please resume activities again. "

S: "Yeah ma'am. You're welcome, ma'am. "

Based on the results of interviews, it is known that in question M1, S2 can illustrate story questions in the form of pictures, S2 also provides information that when S2 solved the questions, S2 was incomplete in illustrating story questions in the form of images because of forgetfulness and haste. In the interview, S2 was able to explain what was known and what was asked about the M1 problem, but it was still incomplete. When S2 was asked to explain the method used and the process, S2 was confused by the formula that had to be used, so S2 had difficulty when asked the calculation process. S2 on the M1 problem does not provide a conclusion.

Error S8 falls into the category of transformation errors, process skills, and writing the final answer. Test and interview results are comparable to the results of resilience in S8 which shows the criteria for moderate mathematical resilience with 4 indicators achievement, namely indicators 1, 2, 5, and 6.

3.3 Subjects with High Resilience

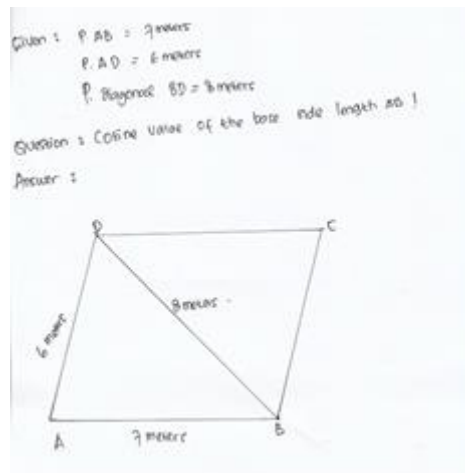


Figure 3. Written Test Results of S3 on M1

Based on Figure 3, it can be obtained that S3 can solve story problems by going through 2 stages, namely the stage of reading questions and understanding questions. However, S6 cannot solve the questions at the stage of transformation, process skills, and writing the final answers.

P: "Next, about number 1. Try reading out question number 1 then what is known and asked about question number 1?"

S: "Number 1 is because Mrs. Tania has a jajargenjang-shaped garden. It is known that the length of the base of the park AB is 7 m, and the length of the sloping side of the park AD is 6 m, while the length of one of the diagonal gardens, BD, is 8 m. Determine the cosine value of the angle formed between the length of the side of the base of the park AB. What is known is the base of the park AB 7 m, the sloping side AD 6 m, and BD 8 m. What's asked cos A." (While illustrating the problem in the form of a picture)

P: "Now, for what is known from the question number 1, you also add a jajargenjang-shaped garden. In terms of the picture is correct. Then, what I want to ask is why did you not solve problem number 3?"

S: "Because the time is up mom."

P: "Oh, I see. Furthermore, from question number 1, is there anything that you don't understand, both in terms of the symbol or the mathematical symbol?"

S: "I was confused and forgot the formula mom."

P: "Oh, I see. Next, do you double check the answers before gathering them?"

S: "No, ma'am."

P: "The last question, why is there an error in writing answers, both from number 1?"

S: "Maybe because I am not thorough, do not understand, and in completing there are also many people who see my friend."

P: "Okay, thank you for the time and information given. Please resume activities again."

S: "Yeah, you're welcome. Thank you too ma'am."

Based on the results of the interview, it is known that in question M1, S3 can illustrate the story problem in the form of pictures. In the interview, S3 can explain what is known and what is asked, but still incomplete. When S3 was asked to explain the method used and the process, S3 was confused and had difficulty when asked the calculation process, because S3 forgot the formula. S3 provides information that when finishing, does not write down the calculation process because the time is up. S3 on the M1 problem does not provide a conclusion.

Error S6 falls into the category of transformation error, process skills, and writing the final answer. Test and interview results are inversely proportional to the resilience results in S6 that show high mathematical resilience criteria with 6 achievement indicators, namely indicators 1, 2, 3, 4, 5, and 6.

CONCLUSION

Based on the results of the location data analysis and the errors made by the eight subjects when solving the triangular data problem, here are the facts. I understand the meaning of the problematic sentence, but the students cannot spell it correctly. Please do not write all the details of the request. Visual problem misunderstandings include not writing what is known, writing what is known to be inconsistent with the question, not writing the question in the question, and writing something not asked in the answer to the question. The error modifying the problems found is: An error writing the formula. Using the wrong method. Do not write the method to use.

Errors of process skills found include: Concept error, Errors in computing, do not continue the settlement procedure (freeze), do not write down the calculation processes. The mistake of writing a final answer is not to write the final answer and conclude according to the content of the problem. Causes of subject errors in solving trigonometric material story problems are: (1) Factors causing reading errors include: lack of confidence, confused in illustrating story problems in the form of images, hurry in solving problems, lack of time management; (2) Factors causing misunderstanding to include: lack of understanding of the problem, hurry in solving problems, forgot to write known and asked Factors causing transformation errors include lack of understanding of the problem, not thorough, hurry in finishing, lack of time management, confused determining which formula to use (trial and error); (3) Factors causing errors in process skills include: lack of understanding of the problem, not thorough, lack of time management; (4) Factors causing the writing of the final answer include: lack of understanding of the problem, accustomed to solving story problems by not writing the conclusions, not thorough, hurry up and forget to conclude.

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