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Analysis of Students' Mistakes in Solving Math Problems: High Level Thinking Skills Based on Mathematical Connection Ability

Erwinda Gracya Laman[1*], Betzy Ayu Omega Rampen[2], Zulfiqar Sulaeman[3], Fitriani Halik[4]
[1,2]Paul's Indonesian Christian University
[3]Agricultural Polytechnic of Pangkajene Islands
[4]State Polytechnic of Creative Media
[1,2]Jl. Perintis Kemerdekaan Km 13, Daya, Makassar, Indonesia
[3]Jalan Poros Makassar Pare-Pare, Km.83, Pangkep, Indonesia
[4]Jl. Perintis Kemerdekaan VI, Tamalanrea Jaya, Makassar, Indonesia
Correspondence Email: erwinda01@gmail.com

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Abstract:
Mathematical connection skills play an important role in solving HOTS questions, but differences in skill levels lead to variations in students' errors in solving mathematical problems. This study aims to describe the errors of students with high, medium, and low mathematical connection skills in solving HOTS mathematical problems. This study is a qualitative study with a descriptive approach conducted at SMPN 12 Makassar. The research subjects were six students selected based on the results of the mathematical connection ability test. The research instruments included a mathematical connection ability test, a HOTS written test, and an interview guide. Student error analysis used Newman's error categories. The results showed that students with high mathematical connection skills made errors in process skills and answer writing, students with medium abilities made errors in transformation, process skills, and answer writing, while students with low abilities made errors in understanding, transformation, process skills, and answer writing. These results indicate that low mathematical connection skills influence the emergence of student errors in solving HOTS problems. Therefore, improving mathematical connection skills needs to be given attention in mathematics learning.

Abstract:
Kemampuan koneksi matematika berperan penting dalam penyelesaian soal HOTS, namun perbedaan tingkat kemampuan tersebut memunculkan variasi kesalahan siswa dalam pemecahan masalah matematika. Penelitian ini bertujuan untuk mendeskripsikan kesalahan siswa dengan kemampuan koneksi matematika tinggi, sedang, dan rendah dalam memecahkan masalah matematika HOTS. Penelitian ini merupakan penelitian kualitatif dengan pendekatan deskriptif yang dilaksanakan di SMPN 12 Makassar. Subjek penelitian berjumlah enam siswa yang dipilih berdasarkan hasil tes kemampuan koneksi matematika. Instrumen penelitian meliputi tes kemampuan koneksi matematika, tes tertulis HOTS, dan pedoman wawancara. Analisis kesalahan siswa menggunakan kategori kesalahan Newman. Hasil penelitian

menunjukkan bahwa siswa dengan kemampuan koneksi matematika tinggi melakukan kesalahan keterampilan proses dan penulisan jawaban, siswa dengan kemampuan sedang melakukan kesalahan transformasi, keterampilan proses, dan penulisan jawaban, sedangkan siswa dengan kemampuan rendah melakukan kesalahan memahami, transformasi, keterampilan proses, dan penulisan jawaban. Hasil ini menunjukkan bahwa rendahnya kemampuan koneksi matematika berpengaruh terhadap munculnya kesalahan siswa dalam menyelesaikan soal HOTS. Oleh karena itu, peningkatan kemampuan koneksi matematika perlu mendapat perhatian dalam pembelajaran matematika.

Keywords:
Student Error, HOTS, Math Connection Ability

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INTRODUCTION

Production in the era of the Industrial Revolution 4.0 is directed at developing 21st century competencies, which consist of three main components. One of the three components is the thinking component, which includes critical thinking, creative thinking, and problem-solving skills. Olivares, Lupianez, and Segovia (2021) argue that problem-solving should be an integral part of the mathematics curriculum. This is because one of the goals of learning mathematics for students is to develop the ability or skill to solve mathematical problems or questions, as a way for them to hone their reasoning skills carefully, logically, critically, analytically, and creatively.

One of the components of mathematical ability is solving mathematical problems (Antao & Morales, 2025). According to Santos-Trigo (2024), problem-solving skills are fundamental competencies in mathematics learning. Son and Fatimah (2020) stated that problem-solving is defined as the process of finding solutions to mathematical problems through certain strategies. Bell (1978) explains that math problem-solving can help students develop their skills and apply them to a variety of situations. To help with good math problem-solving skills, several abilities are needed, one of which is high-level thinking skills.

Higher Order Thinking Skills (HOTS) refers to students' thinking activities that involve a higher cognitive level than Bloom's Taxonomy, including analyzing, evaluating, and creating (Anderson & Krathwohl, 2015). According to Liline, HOTS-based learning can develop higher-level thinking skills such as creative thinking skills, analytical thinking skills, and metacognitive thinking skills (Rampean & Rohaeti, 2025). HOTS is a skill that is more than just remembering, understanding, and applying (Dahlan, Permana, & Oktariani, 2020). HOTS questions are questions that encourage students to think at a higher level. They are directed to think critically and creatively when facing problems. According to Lewis and Smith (1993), high-level thinking skills occur when a person takes new information and information that is already stored in their memory, then connects and relays it to achieve a goal or get the answers needed. Therefore, to face the era of globalization and the era of the industrial revolution 4.0, in mathematics education, students are trained and used to working on problems involving HOTS.

Math connection skills greatly support high-level thinking skills in solving math problems. This is because HOTS-type questions are generally multi-conceptual, connecting not only concepts in mathematics but also with other disciplines. Therefore, high-level thinking skills can be analyzed based on mathematical connection skills. According to Hard, Wahyudi, Suyitno, Kartono, & Sukestiyarno (2018), the ability to connect mathematics helps a person to understand mathematical functions, improve mathematical concepts, determine correlations between mathematical concepts, and identify the application of mathematics in the surrounding environment. NCTM (2000) categorizes mathematical connections into three categories: connections between mathematical topics, connections with other disciplines, and connections in everyday life. According to Mousley, three aspects of mathematical connections include (a) the relationship between new mathematical knowledge and pre-existing mathematical knowledge; (b) the relationship between mathematical concepts; and (c) the relationship between mathematics and daily life (Rawa & Sudirman, 2016). According to Anthony and Walshaw in Mhlolo, Schafer, & Venkat (2012), the ability to learn to make connections in mathematics is essential for conceptual understanding. This opinion emphasizes that the ability to make mathematical connections is one of the most important abilities in learning mathematics, as it can enrich students' conceptual understanding. Mathematical connection skills need to be developed in every student because it is the basis for mastering various materials and forms of mathematical problem solving, especially HOTS-type questions.

When solving HOTS math problems, students often encounter difficulties, which can lead to errors. Based on interviews conducted by researchers with mathematics teachers at SMPN 12 Makassar, several problems were identified in the learning process, especially in grade IX. Students' mathematical connection abilities are still relatively low, although some students have relatively high levels. This comparison was shown by the teachers in their responses to the problem of square functions given in classes IX.4 and IX.6. Of the total number of students in the class, only 30% were able to solve quadratic function problems and had high mathematical connection skills, while 70% were unable to solve quadratic function problems and also had low mathematical connection skills. Based on the results of interviews with students of SMPN 12 Makassar grades IX.4 and IX.6, it was found that students had difficulty in solving HOTS problems because the practice questions given by the teacher were different from the questions explained during the learning process and some students understood mathematics learning during the learning process and in the next meeting students had forgotten the learning learned in the previous meeting. This is because some students only memorize formulas instead of understanding concepts and have difficulty connecting one concept to another.

Syarnubi, Efriani, Pranita, Zulhijra, Anggara, Alimron, and Rohmadi (2024) emphasized that students' mistakes when working on HOTS-type problems include a lack of motivation in learning, student inaccuracy, a lack of ability to solve HOTS problems, a lack of understanding in doing mathematical calculations, and a lack of understanding of concepts. Many schools have not implemented higher-level thinking questions. Research by Susilowati and Ratu (2018) shows that the most common mistakes made by students are process skills errors and notation errors. To overcome these errors, error analysis is performed. Error analysis aims to identify the types of mistakes that students make. One of the procedures that can be used to determine the cause of errors in solving mathematical problems, specifically HOTS problems, is the Newman criterion.

In this study, student errors refer to the types of errors identified by Newman (Syarnubi, Efriani, Pranita, Zulhijra, Anggara, Alimron, & Rohmadi, 2024), which consist of five categories: reading errors, comprehension errors, transformation errors, process skill errors, and coding errors. Based on the Newman Criteria, mistakes or mistakes made by students can be identified. This makes the author interested in further researching students' mistakes in solving HOTS problems from the perspective of mathematical connection ability. Therefore, based on this description, it is necessary to better understand the mistakes made by students in solving HOTS problems and mathematical concepts in general. By understanding this, teachers will be able to anticipate the learning process of related math concepts and prevent mistakes from occurring in the future.

Some relevant research results are as follows: Septiani, Sugiyanti, and Rubowo (2021) research entitled "Profile of Creative Thinking Ability in Solving HOTS Problems Seen from Medium Mathematical Connection Ability". This shows that students still have difficulty in solving HOTS problems due to the low-level thinking ability of Indonesian students, as shown in PISA, and the lack of students' mathematical connection skills, namely the ability to understand mathematical concepts. Saputra's research (2023) entitled "The Mathematical Connection Ability of Madrasah Tsanawiyah Type Climber Students in Solving High-Order Thinking Skills Problems" shows that mathematical connections need to be used in solving HOTS problems, because it requires a relationship between the knowledge that has been obtained and the knowledge to be learned in solving a problem. Febryana, Sudiana, and Pamungkas research (2023) entitled Analysis of Student Errors in Solving HOTS Mathematical Problems Based on Newman's Theory shows that there are 5 types of categories of errors made by students in solving Higher Order Thinking Skills (HOTS) Mathematics Problems with the topic of linear equations based on Newmann error analysis, namely reading errors, misunderstandings, transformation errors, processing skill errors, and coding errors.

The novelty of this study lies in its focus on analyzing students' errors in solving Higher-Order Thinking Skills (HOTS) mathematical problems in terms of mathematical connection ability, based on Newman's error analysis criteria, which have not been previously studied by researchers. Previous studies have reported that students often make mistakes due to a weak understanding of conceptual relationships; however, the study did not provide a detailed explanation of how mathematical connections affect students' thinking processes in solving HOTS problems, and was limited only to classifying the types of errors.

METHODS

This research is a qualitative study with a qualitative descriptive approach. This research was conducted at SMPN 12 Makassar during the second semester of the 2024/2025 academic year. The research subjects consisted of ninth-grade students at SMPN 12 Makassar. Two heterogeneous classes were selected from the ninth grade based on a recommendation from a math teacher to administer a math connection ability test. The selection of research subjects was determined from the results of the mathematical connection ability test, after which students were categorized into three groups of high, medium, and low mathematical connection skills.

From this categorized group, two students from each category were selected to represent their respective groups and then given a Higher-Order Thinking Skills (HOTS) question about the quadratic function. After this, the students were interviewed regarding the answers they had written, and their errors were analyzed using the Newman Error Analysis criteria. The Newman criteria were chosen because they provide a systematic analytical structure to identify errors at the reading, comprehension, transformation, process skills, and coding stages, thus allowing researchers to uncover the sources of misunderstandings more specifically.

Because there is more than one potential subject in the high, medium, and low categories, the research subjects are selected based on the following criteria: (1) the ability to communicate or articulate their thoughts, in which case the researcher seeks the recommendation of the math teacher and considers peer input; and (2) the subject's willingness to participate in data collection during the study. The selection of six subjects was considered relevant and proportionate to conduct a detailed error analysis in the context of HOTS problem-solving from the perspective of mathematical connection capabilities.

There are three categories of mathematical connection capabilities shown in table 1 below.

Table 1. Categories Math Connection Ability

Student score	Categories: Math Connection Ability
$70 \leq x \leq 100$	Height
$50 \leq x \leq 70$	Medium
$0 \leq x < 50$	Low

Source: Setialesmana, Anisa, and Herawati (2017)

The instruments used in this study are the researcher himself as the main instrument, the Mathematical Connection Ability Test, HOTS mathematics questions, and interview guidelines.

The data collection technique in the research was carried out through the administration of tests and interviews. The tests used include: (1) Mathematical connection ability test, given to determine students' ability in the relationship between mathematical concepts, the relationship between mathematics and other sciences, and the relationship between mathematics and daily life, to take research subjects that will be given HOTS mathematics problems. (2) HOTS math test questions, given to students to reveal students' mistakes in solving HOTS math problems. After completing the test questions, the interview is conducted as a triangulation tool to verify the answers written by the research subjects and identify errors in their responses to the given questions. The validity of the data is determined through technical triangulation, which involves comparing the data obtained from the HOTS test questions with the data collected from the interviews.

The data analysis in this study consists of three steps (Miles, Huberman, & Saldana, 2014), including: (1) Data condensation. At this stage, the researcher first compiles the interview transcript based on the recordings between the researcher and the subject. Then the researcher encoded each item in the interview transcript. Then, the items are summarized by selecting only the interview transcript items that correspond to the research question. (2) Data presentation. At this stage, the researcher analyzes the subject's errors based on the results of interview transcripts and written tests conducted during the previous data condensation process. (3) Conclude. At this stage, the researcher compared the written results with the interview transcripts that were previously condensed through a technical triangulation process. The results of this technical triangulation are a reference for researchers in their conclusions.

RESULTS AND DISCUSSION

Based on the results of the mathematical connection ability test of ninth-grade students of SMPN 12 Makassar, six students were selected as research subjects, consisting of two students with high mathematical connection ability, two with medium mathematical connection ability, and two with low mathematical connection ability. The details of each selected subject are presented in the following table.

Table 2. Determination of Research Subjects

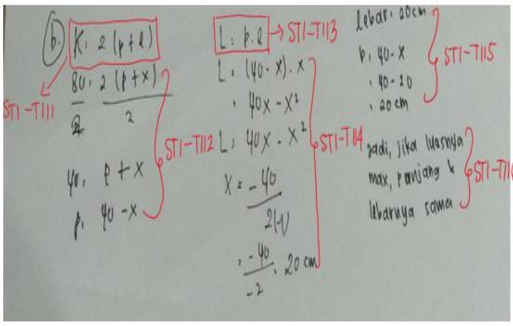
No	Student Initials	Connection Capabilities	Test Scores	Student Code
1	BV	Height	100	ST1
2	LB	Height	100	ST2
3	I	Medium	60	SS1
4	IE	Medium	60	SS2
5	YES	Low	25	SR1
6	SR	Low	12,5	SR2

1. Subject Errors with High Math Connection Ability

a. Process Skills Errors

In figure 1, it can be seen that when solving the problem, the subject made a mistake in replacing the circumference value, which led to the wrong solution step because the information entered into the formula was wrong. (ST1-T112, ST1-T114, ST1-T115).

Original Version:



Translated Version:

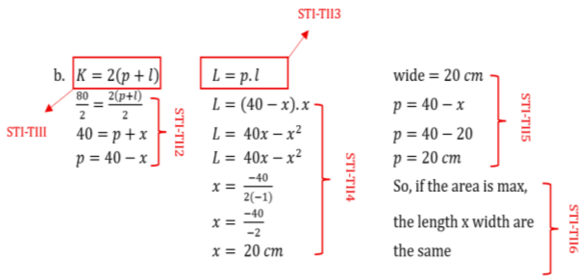


Figure 1. Results of The HOTS Written Test of Subjects with High Mathematical Connection Ability (ST1)

The following is an excerpt of the subject's interview regarding the written answer.

Transcript 1

P	:	Is the circumference 80 cm?
ST1-W132	:	Yes
P	:	But in the question of circumference = 80 cm, isn't that just for part a?
ST1-W133	:	In my opinion, a and b are related, so in part b, a

circumference of 80 cm also applies, and in part a, I have obtained the maximum length and width. So, if the length and width are maximum, the area must also be maximum.

P : So, what are the steps to overcome it?

ST1-W134 : What I wrote is the same as part a; the only difference is in the conclusion.

Transcript 1 shows that the subject was wrong because he thought that K = 80 cm also applied to part b of the problem, so the subject inserted an inaccurate value into the formula used and assumed that the steps to solve parts a and b of the problem were the same, although there were slight differences, especially in the circumference values (ST1-W132, ST1-W133, ST1-W1z34). Based on the data of written answers and interview results, it was shown that the subjects made process skills mistakes.

b. Coding Errors

In figure 2, it can be seen that the subject writes an incomplete answer, i.e., the subject does not write the quarter for the width of the rectangle obtained (ST2-T117).

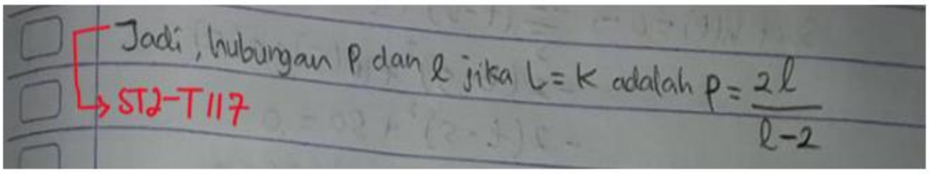


Figure 2. Results of The HOTS Written Test of Subjects with High Mathematical Connection Ability (ST2)

Transcript 2

P : You've already got it, so to know the value of p, you just take any number without a specific term? $p = \frac{2l}{l-2}$

ST2-W125 : Yes

P : So, I can take a negative number for example, -2?

ST2-W126 : Cannot have a negative length or width

P : What about zero?

ST2-W127 : Cannot be 0 or negative

P : What about 2?

ST2-W127 : Can

P : If it is 2 cm wide, how long will it be?

ST2-W128 : Yes, I'll try to count it (while writing and counting the results). The result seems to be that I was wrong $\frac{0}{0}$

P : So, how should it be?

ST2-W129 : I have to add that the length of my answer should not be 0, negative, or 2

P : If so, why not write it down?

ST2-W130 : I just realized

Transcript 2 shows that the subject is able to explain the terms that should be in the final answer or conclusion on the answer sheet, but the subject does not write the terms for width, so that the value is not defined, and only realizes that the terms must be written so that the answer is complete and correct. (ST2-W125, ST2-W126, ST2-W127, ST2-W128, ST2-W129, ST2-W130). Based on the written answer data and the results of the interview, it was shown that the subject made a coding error.

2. Subject Errors with Medium Math Connections

a. Transformation Error

In figure 3, it can be seen that when solving the problem, the subject did not write down the correct formula used to solve it (SS1-T110).

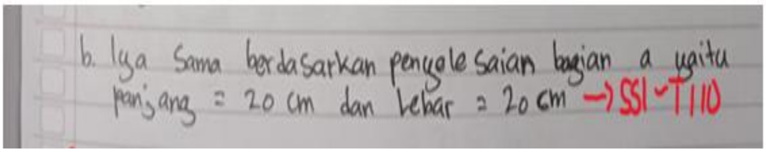


Figure 3. Results of The HOTS Written Test of Subjects with Medium Mathematical Connection Ability (SS1)

The following is an excerpt of the subject's interview based on written answers.

Transcript 3

P : What formula is used in part b?

SS1-W128 : There is no need to use a formula or method for part b, because from answer a, the length and width are both 20 cm, meaning they are both the same.

P : Are questions a and b related?

SS1-W129 : Yes related

Transcript 3 shows that the subject relies only on the answers for part a to complete part b and assumes that part b does not need to use the formula, even though the formula used is the same for parts a and b, the subject still has to write it down because there is a different value, called circumference. (SS1-W128, SS1-W129). Based on the written answer data and interview results, it was shown that the subject made a transformation error.

b. Process Skills Errors

Figure 4 shows that the subject did not write down the solution steps in section b and could not determine the relationship between length and width in section c with the correct solution steps (SS1-T111, SS1-T112).

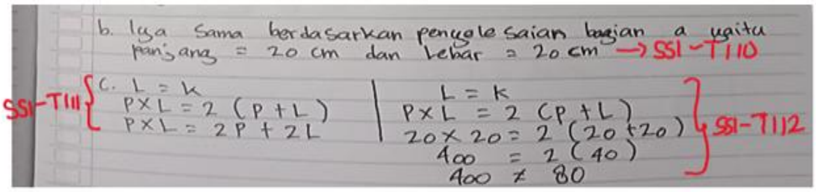


Figure 4. Results of The HOTS Written Test of Subjects with Medium Mathematical Connection Ability (SS1)

The following is an excerpt of the subject's interview based on written answers.

Transcript 4

P	:	How do I complete part b?
SS1-W128	:	There is no need to use the method for part b, as it can be answered directly. From answer a, we know that length = 20 cm and width = 20 cm, meaning that the length and width are the same.
P	:	If part c, what are the steps to address it?
SS1-W132	:	I write because it is known that the area is equal to the circumference. Next I write the formula obtained, I enter the $L = K p \times l = 2(p + l) p \times l = 2p + 2l$ values of length and width, $20 \times 20 = 2(20 + 20)$ I solve it so that the area is 400 and the circumference means $400 = 2(40)\ 80\ 400 \neq 80$

Transcript 4 shows that the subject explained that for part b, there was no need to use a method or solution step because this problem was related to part a (SS1-W128). In the solution step for section C, the subject explains that it is 20 cm long and 20 cm wide, or in other words, the problem in section C is still related to section A. Although the length and width values for section C are not yet known, the subject also focuses on determining the width and circumference values, although there are questions asking about the relationship between length and width (SS1-W132). Based on the data of written answers and interview results, it shows that the subjects made mistakes in process skills.

c. Coding Errors

In Figure 5, it can be seen that the subject did not write the final answer and conclusion correctly (SS1-T110, SS1-T113).

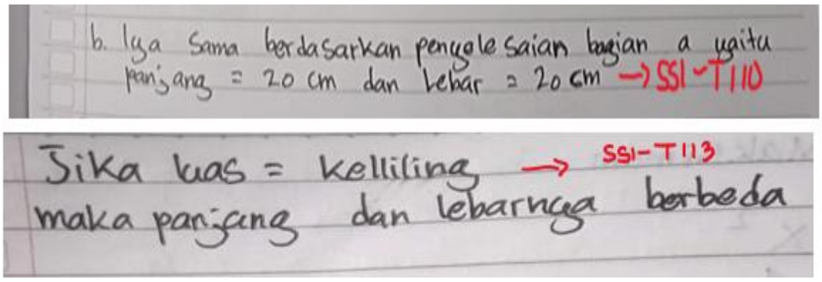


Figure 5. Results of The HOTS Written Test of Subjects with Medium Mathematical Connection Ability (SS1)

The following is an excerpt of the subject's interview based on written answers.

Transcript 5

P	:	What conclusion is drawn in part b?
SS1-W131	:	The length and width are the same based on the solution of part a, length = 20 cm, and width = 20 cm.
P	:	What conclusions are drawn in section C?
SS1-W134	:	If the area is equal to the circumference, then the length and width are different.
P	:	Are you sure your answer is correct?
SS1-W137	:	Yes, of course

Transcript 5 shows that in part b, the subject explained that it was 20 cm long and 20 cm wide, based on the solution of part a. The subject relies solely on the answers to part a to conclude part b without providing any supporting evidence. For section c, the subject simply explains that if the area is equal to the circumference, it means that the length and width are different, although what is being asked is the relationship between the length and width of the rectangle (SS1-W131, SS1-W134, SS1-W137). Based on the written answer data and the results of the interview, it shows that the subject made a mistake in writing the answer (coding error).

The following is a summary of the subject's errors regarding the ability to make medium mathematical connections:

1) Transformation Error, where the subject does not write the correct formula used to solve the problem.
2) Process Skill Errors, where the subject does not perform the completion steps correctly, there are missed completion steps, and make mistakes in arithmetic operations.
3) Mistakes in writing Answers Writing Errors, the subject does not write the final answer and conclusion correctly.

   According to Yuwono, Londar, and Suwanti (2020), students with moderate connection skills can effectively connect concepts but struggle to implement plans and review the results of their work.

3. Subject Errors with Low Math Connections

a. Reading Errors

In figure 6, it can be seen that the subject did not read the question completely, with some words missing. For example, the subject writes "The student cut a rectangular piece of cloth," when in fact the student was supposed to cut a piece of cloth that produced a rectangle. Some words are not read or written by the subject entirely (SR2-T11).

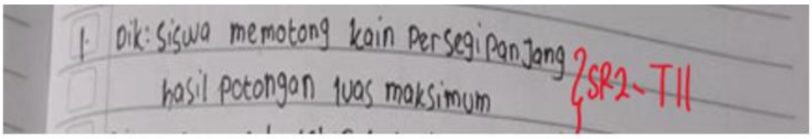


Figure 6. Results of The HOTS Written Test of Subjects with Low Mathematical Connection Ability (SR2)

The following is an excerpt of the subject’s interview based on written answers.

Transcript 6

P	:	For question number 1, can you read?
SR2-W14	:	(when reading the question) A student will cut a rectangular piece of fabric, and is expected to get the maximum cut area.

Transcript 6 shows that the subject did not read the question thoroughly and skipped certain words, but was unaware of this (SR2-W14). Based on the data of written answers and interview results, it shows that reading errors were made.

b. Misunderstanding

Figure 7 shows that the subject did not record all the information from the question, including the known information and the information requested (SR2-T11, SR2-T12).

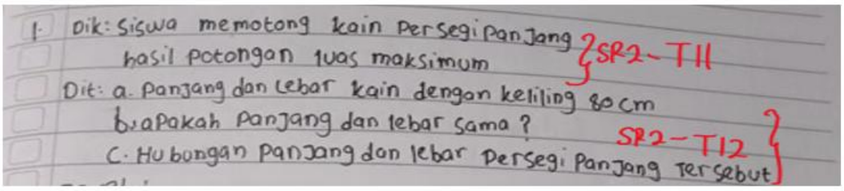


Figure 7. Results of The HOTS Written Test of Subjects with Low Mathematical Connection Ability (SR2)

The following is an excerpt of the subject's interview based on written answers.

Transcript 7

P1-W09	:	What is known from the question?
SR2-W19	:	Students cut rectangular fabrics; the maximum area is the cut
P1-W110	:	What is being asked in that question?
SR2-W110	:	The length and width of the fabric with a circumference of 80 cm, are the length and width the same? And the relationship between the length and width of the rectangle!

Transcript 7 shows that the subject did not fully explain the information obtained from the question. There is still important information from the question that was not mentioned by the subject (SR2-W19, SR2-W110). Based on the data of written answers and the results of the interview, it shows that the subject made a misunderstanding.

c. Transformation Error

Figure 8 shows that the subjects did not write down the complete formulas used in the problem-solving process (SR2-T13, SR2-T18, SR2-T19).

The following is an excerpt of the subject's interview based on written answers.

Transcript 8

P	:	What formula do you think is used to solve the problem?
SR2-W117	:	Rectangular circumference
P	:	Why do you use this formula?
SR2-W119	:	Since its circumference is 80 cm, it should be used; However, I'm not sure if there are any other formulas I should use.

Transcript 8 shows that the subject did not mention all the formulas that should have been used in solving the problem. The subject mentions only one formula, which is the circumference of a rectangle, and the subject also explains that the subject does not understand that there are other formulas used in solving the problem (SR2-W117, SR2-W119). Based on the data of written answers and interview results, it shows that the subject made a transformation error.

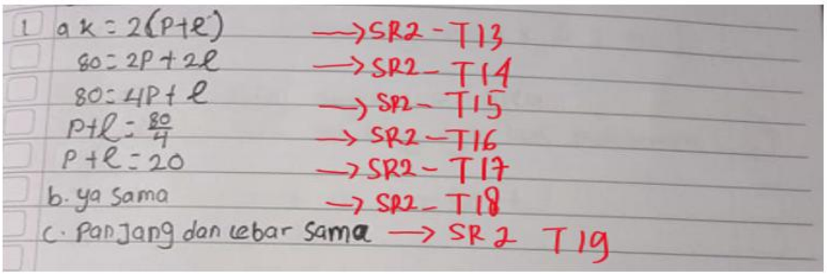


Figure 8. Results of The HOTS Written Test of Subjects with Low Mathematical Connection Ability (SR2)

d. Process Skills Errors

Figure 8 shows that, in part a, the subject did not write down the solution steps completely, and there were steps that the subject missed. In sections b and c, the subjects do not record the solution steps but rather write down the final answer (SR2-T14, SR2-T15, SR2-T16, SR2-T17, SR2-T18, SR2-T19). The following is an excerpt of the subject's interview based on written answers.

Transcript 9

P	:	Pay attention to the answer, where did you get 4p+l??
SR2-W122	:	$2p + 2 = 4p$
P	:	Can you add 2p + 2??

SR2-W123	:	Yes
P	:	But what you wrote was 2p + 2l, why did it become 4p + l?
SR2-W124	:	$2p + 2 = 4p$ and there is still l left so $4p + l$
P	:	Where do you get it from? $?p + l = \frac{80}{4}$
SR2-W125	:	From here, due to its length and width can be found $80 = 4p + lp + l = \frac{.80}{4}$
P	:	Can you instantly divide 80 by 4?
SR2-W126	:	Possible
P	:	Can you explain how to complete parts b and c?
SR2-W132	:	No one knows, just guess.

Transcript 9 shows that in the answer part a, the subject made a mistake in adding $2p + 2$ so that the subject got the wrong result. The subject also makes mistakes in solving, and the subject is unable to explain the solution steps correctly. In sections b and c, the subjects are unable to explain the solution steps because they do not understand and only guess the answers they wrote (SR2-W122, SR2-W123, SR2-W124, SR2-W125, SR2-W126, SR2-W132). Based on the data of written answers and interview results, it shows that the subjects made mistakes in process skills.$4p80 = 4p + lp + l = \frac{80}{4}$

e. Coding Errors

Figure 8 shows that the subject was unable to write the answers and conclusions correctly (SR2-T17, SR2-T18, SR2-T19). The following is an excerpt of the subject's interview based on written answers.

Transcript 10

P	:	So, what is the final answer?
SR2-W127	:	$p + l = 20$
P	:	So, what is the length and width of the fabric?
SR2-W128	:	20
P	:	Is it 20 long or wide?
SR2-W129	:	Both hmm, I'm confused.
P	:	What about part b? What is the answer?
SR2-W130	:	Same
P	:	What is the same?
SR2-W131	:	Length and width
P	:	What is the answer to part c?
SR2-W134	:	Equal length and width

Transcript 10 shows that the subject made a mistake in determining the final answer. In section a, the subject explains that the final answer is p + l = 20. The subject also explained that it was equal to 20 in length and 20 in width, but was not sure because the subject did not understand the meaning of the question. In part b, the subject answers "yes, they are the same." The subject explains that the same thing is long and wide, but the subject cannot explain why. In part c, the subject explains that length and width are the same, even though what is asked is the relationship between length and width when the area equals the circumference. The subject cannot fully explain the answer and cannot provide logical reasons (SR2-W127, SR2-W28, SR2-W129, SR2-W130, SR2-W131, SR2-W134). Based on the written answer data and the results of the interview, it shows that the subject made a mistake in writing the answer (coding error).

The results of this study show that students' mistakes in solving HOTS mathematics problems in Class IX of SMPN 12 Makassar vary according to the level of their mathematical connection ability. These findings reinforce the view that mathematical connection skills are an important component in solving problems that require a high level of reasoning, as they allow students to meaningfully connect various concepts and problem-solving strategies (Jawad, 2022). Students with high-level math connection abilities show fewer errors, while those with low levels tend to make mistakes at almost every stage of the problem-solving process.

Students with high mathematical connection abilities make mistakes, in particular: (1) Process Skill Error, in which the subject performs the wrong solution steps, makes incorrect arithmetic operations, such as substituting the wrong value of the question; (2) Errors in Writing Answers, where the subject cannot correctly determine the final answer and conclusion. According to Yuwono, Londar, and Suwanti (2020), students with high-category connection skills are able to connect mathematical concepts effectively, ensuring that each stage of problem solving is carried out smoothly. According to Hidayati, Triyana, Gunawan, Kusno, & Jaelani (2025), students with high mathematical ability have excellent connections by meeting every indicator of mathematical connection. In line with Jawad (2022), students with high problem-solving skills demonstrate proficiency in all indicators of mathematical connection, including understanding and applying the relationships between mathematical ideas, connecting mathematics with other subjects, and connecting mathematics with daily life. Jailani, Retnawati, Apino, and Santoso (2020) states that high category students can write, analyze, and understand information correctly and precisely; able to convert mathematical concepts into mathematical language or symbols but is not precise in writing variables; able to write mathematical models in a complete, coherent, and correct manner; Be able to write the conclusion of the answer correctly and completely in their own language.

Students with mathematical connection abilities are making mistakes, in particular: (1) Transformation Errors, where the subject does not write the correct formulas used to solve the problem; (2) Process Skill Errors, where the subject does not perform the completion steps correctly, there are missed completion steps and make mistakes in arithmetic operations; (3) Mistakes in writing Answers Writing Errors, the subject does not write the final answer and conclusion correctly. According to Yuwono, Londar, and Suwanti (2020), students with moderate connection skills can effectively connect concepts but struggle to implement plans and review the results of their work. Jawad (2022) states that Students with moderate abilities meet these two indicators, demonstrating an understanding of mathematical relationships and real-life applications. Jailani, Retnawati, Apino, and Santoso (2020) states that students in the media category can write, analyze, and understand information correctly and precisely; able to convert mathematical concepts into mathematical language or symbols but is not precise in writing variables; able to write mathematical models correctly, completely and coherently; I have not been able to write the complete conclusion of the answer but only the final result.

Students with low math connection ability make mistakes, in particular: (1) Reading Errors: Subjects cannot correctly read important words of the question or key information; (2) Misunderstanding: The subject does not write down the information obtained from the question fully and does not understand the meaning of the question; (3) Transformation Error: The subject cannot determine the correct formula used to solve the problem; (4) Error Process Skills occur when the subject cannot determine the correct solution step because he does not understand the meaning of the problem. The subject makes mistakes in calculation operations, such as division and addition; (5) Coding Errors: Subjects do not fully understand the concepts and how to solve questions, so they cannot correctly determine the final answer and conclusion. According to Yuwono, Londar, and Suwanti (2020), students with low connection skills are unable to connect concepts, which prevents them from understanding the problem well. As a result, they are unable to formulate a problem-solving plan, which leads to many errors in problem-solving. Jawad (2022) states that students with low abilities only meet the basic requirements of understanding mathematical ideas. This suggests that different levels of problem-solving skills correlate with students' understanding of mathematical connections, highlighting the importance of targeted interventions in teaching practice. Jailani, Retnawati, Apino, and Santoso (2020) state that teachers in the low category are only able to make mathematical concepts into mathematical language or symbols, but are not appropriate in writing variables; Be able to write a complete, coherent mathematical model, but it is wrong because the result does not match the instructions in the problem.

Based on research that examines the factors that affect students' mistakes through Newman error analysis, it is concluded that the types of mistakes made by students in solving HOTS questions include reading errors, comprehension errors, transformation errors, process skill errors, and coding errors. Factors that contribute to this error are a lack of conceptual understanding, deficiencies in the thought process, forgetfulness, inaccuracies, lack of knowledge of formulas and problem-solving procedures, as well as the influence of errors that occurred at the previous stage. This is in line with Syarnubi (2024); the reasons for student errors are a lack of motivation in learning, student inaccuracy, a lack of ability to solve HOTS problems, a lack of understanding in doing mathematical calculations, and a lack of understanding of concepts.

CONCLUSION

Students with high math connection skills make two types of mistakes in solving HOTS math problems, based on Newman's criteria: process skill errors and coding errors. Students with math connection skills are making three types of mistakes in solving HOTS math problems, based on Newman's criteria: transformation errors, process skill errors, and coding errors. Students with low math connection skills made five types of errors in solving HOTS math problems, based on Newman's criteria: reading errors, comprehension errors, transformation errors, process skill errors, and coding errors.

This research is limited to mathematical connection capabilities. Therefore, other factors that can influence student errors have not been analyzed. The scope of this study is also limited, focusing only on student errors in solving HOTS math problems on quadratic functions without further investigating the causes of these errors. For future researchers, it is recommended to explore other factors that affect students' mathematical connection ability to solve HOTS math problems, as well as strategies to address them, such as effective instructional approaches, the use of technology in learning, and the impact of the learning environment on the development of students' mathematical abilities.

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