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The Failure of National Madrasah Science Competition Students in Solving Islam-Integrated Mathematics Problem on Triangle Material

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ABSTRACT

Students, especially madrasah students, need to master Islamic integrated mathematics problem-solving. However, many madrasah students need help to solve Islamic-integrated mathematics problems. The failure occurs in one part and several interrelated parts of the solution. Therefore, this study aims to explore the failure of madrasah science competition students at the national level in solving Islamic integrated mathematics problems on triangle material. The research was conducted qualitatively on 29 students at the *Madrasah Tsanawiyah* (MTs) or equivalent level who participated in the national madrasah science competition, and they failed to solve Islamic integrated mathematics problems on triangle material. The research instrument was a triangle problem given during the National Madrasah Science Competition (KSM) in 2023. The results showed five categories of failure: failure to provide a correct and complete process, failure to integrate Islamic values, failure to use mathematical concepts, failure to use mathematical principles, and failure to apply relevant strategies. This research contributes to teachers by characterizing student failures that can be used as a guideline in designing learning strategies that can overcome student failures. In addition, teachers can provide scaffolding to students according to the type of failure.

Keywords**:** *Mathematics Problem Failure, Madrasah Science Competition, Islamic Integrated Mathematics, Triangle.*

Kegagalan Siswa Kompetisi Sains Madrasah Nasional dalam Menyelesaikan Soal Matematika Terintegrasi Islam pada Materi Segitiga

ABSTRAK

Pemecahan soal matematika terintegrasi Islam perlu dikuasai oleh siswa, khususnya siswa madrasah. Namun, banyak siswa madrasah yang gagal dalam menyelesaikan soal matematika terintegrasi Islam. Kegagalan tersebut tidak hanya terjadi pada satu bagian, tetapi dalam beberapa bagian penyelesaian yang saling berkaitan. Oleh karena itu, tujuan penelitian ini yaitu untuk mengeksplorasi kegagalan siswa kompetisi sains madrasah tingkat nasional dalam menyelesaikan soal matematika terintegrasi Islam materi segitiga. Penelitian dilakukan secara kualitatif terhadap 29 siswa jenjang Madrasah Tsanawiyah (MTs)/sederajat yang menjadi peserta kompetisi sains madrasah tingkat nasional dan mereka gagal dalam menyelesaikan soal matematika terintegrasi Islam pada materi segitiga. Instrumen penelitian berupa soal segitiga yang diberikan saat Kompetisi Sains Madrasah (KSM) Nasional tahun 2023. Hasil penelitian menunjukkan adanya lima kategori kegagalan, yaitu kegagalan memberikan proses yang benar dan lengkap, kegagalan mengintegrasikan nilai-nilai Islam, kegagalan menggunakan konsep matematis, kegagalan menggunakan prinsip matematis, dan kegagalan menerapkan strategi yang relevan. Penelitian ini berkontribusi bagi guru berupa karakterisasi kegagalan siswa yang dapat digunakan sebagai pedoman dalam merancang strategi pembelajaran yang dapat mengatasi kegagalan siswa. Selain itu, guru dapat memberikan scaffolding kepada siswa sesuai jenis kegagalan yang dialami siswa.

Kata Kunci: *Kegagalan Masalah Matematika, Kompetisi Sains Madrasah, Matematika Terintegrasi Islam, Segitiga*.

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1. Introduction

As part of education, mathematics learning is responsible for forming students with character and morality (Abdussakir & Rosimanidar, 2017). This responsibility is confirmed in the Law of the Republic of Indonesia number 20 of 2003, which states that one of the objectives of education is to release the potential and make students pious to God Almighty (Undang-Undang Republik Indonesia, 2003). Mathematics learning plays a role in training thinking and reasoning skills and shaping students' morals (Alghar et al., 2023; Cipta & Hori, 2018). Therefore, a unique approach is needed that involves religious aspects and religious values in learning mathematics. One approach that can be used is through integrative mathematics.

Integrative mathematics is an approach that links, merges, and connects mathematics with various disciplines (Kelley & Knowles, 2016; White, 2014). This integration is not limited to linking alone but also includes building correlations and perfecting between sciences to become a whole knowledge (White, 2014). Several forms of integrative mathematics have been formulated, such as mathematical approaches with science, technology, engineering, and art known as STEAM (Bedewy & Lavicza, 2023; Margot & Kettler, 2019; Rosikhoh et al., 2019), mathematical approaches with cultural scope known as ethnomathematics (Alghar & Marhayati, 2023; Amalia et al., 2021; Prahmana, 2022; Sulistyawati & Rofiki, 2022), and mathematical approaches with Islamic religious values known as Islamic integrated mathematics (Alghar et al., 2023; Alghar & Afandi, 2024; Hendrawati et al., 2020).

Islamic integrated mathematics is an approach that links, connects, and integrates mathematical concepts and principles with Islamic values (Abdussakir, 2014; Abdussakir & Rosimanidar, 2017). Islamic values can be sourced from the Quran, hadith, history of Islamic civilization, *fiqh*, and Islamic law (Radjak, Alghar, & Cholidiyah, 2023; Rosikhoh & Abdussakir, 2020). Islamic integrated mathematics uses the context of everyday problems related to Islam, such as worship, Islamic behavior, and trade following Islamic law (Sugilar et al., 2019; Supriyadi, 2020). Thus, Islamic integrated mathematics problems are defined as problems with Islamic values or contexts sourced from the Al-Quran, hadith, history of Islamic civilizations, *fiqh*, or *akidah akhlak*.

Islamic integrated mathematics cannot be separated from various Islamic-based educational institutions. In Indonesia, various educational institutions, from elementary to university levels, are based on Islam (Bafadhol, 2017; Rahman, 2018). This is shown by the existence of *Raudhatal Atfal* (Ilamic kindergarten), *Madrasah Ibtidaiyyah* (Islamic-based elementary school), *Madrasah Tsanawiyyah* (Islamic-based junior high school), *Madrasah Aliyah* (Islamic-based senior high school), and Islamic-based universities such as STAIN, IAIN, and UIN (Bafadhol, 2017; Hapiz et al., 2019). Islamic integrated mathematics is applied and developed in these institutions. Some teachers have implemented Islamic-integrated mathematics at the madrasah level (Safitri et al., 2020).

The development of Islamic integrated mathematics is increasingly evident with the Madrasah Science Competition (KSM). KSM is a competition organized by the Ministry of Religious Affairs to build a competitive spirit at the Islamic-based school level (Maulana & Mutmainah, 2018). KSM was held for the first time in 2012 and is still held yearly (Maulana & Mutmainah, 2018). KSM is distinguished from other competitions because the questions are integrated with Islamic values, such as using the context of Islamic problems, questions made in Arabic, and linking Islamic sources (Maulana & Mutmainah, 2018; Sofiyana, 2021). This applies to all school levels and all fields of competition, including mathematics. One Islamic integrated math problem at KSM is the triangle problem.

Triangle problems are related to triangles belonging to Euclid geometry (Mulyati, 2000). Although simple, the triangle problem is still an obstacle that makes it difficult for students. Some students are thought to understand the concepts of Pythagoras, triangle congruence, and triangle area. However, when these concepts are combined in the form of mathematical problems, many students fail to solve them (Amaliah et al., 2021; Indraswari et al., 2019; Nugrawati et al., 2018).

Failure to solve math problems is defined as the inability of students to solve math problems appropriately (Kapur, 2010). In their research, Goos (2002) and Huda et al. (2019) explained that failure in solving mathematical problems is categorized into three parts: metacognitive blindness, metacognitive vandalism, and metacognitive mirage. Meanwhile, Kurniawan et al. (2018) categorized student failure in solving mathematical problems based on process and results. Someone is said to have successfully solved a math problem if a series of methods and results obtained are correct. If the process, results, or both are wrong, then it is said to be a failure. Thus, failure in solving math problems is defined as a person's inability to solve math problems correctly or entirely.

Failure to solve triangle problems will impact the failure of other mathematical concepts because many mathematical concepts make triangles the basic concepts, such as trigonometry, building space, surface area of flat planes, and angles. This statement is reinforced by various studies that show that students' failure in triangles causes difficulties in understanding trigonometry, determining the volume of a prism, and selecting the area of a flat plane (Amaliah et al., 2021; Linda et al., 2020; Listiyana, 2012; Portuna et al., 2023). This failure has a domino effect on the failure of other math concepts in the future.

Several studies have explored students' errors and failures in solving triangle problems. Research by Biber et al. (2013) and Indraswari et al. (2019) analyzed student errors in solving triangle angles. Linda et al. (2020) identified student errors based on Van Hiele's theory. Research by Indraswari et al. (2019) analyzed student errors in solving geometry HOTS problems. Nugrawati et al. (2018) and Amaliah et al. (2021) examined students' difficulties in solving triangular problems based on mathematical communication skills. Kurniawan et al. (2018) explored students' failure in constructing triangular fraction problems.

Although previous research presents student failure in solving triangle problems, the aspects studied are limited to simple ones. The triangle inequality problem given in Indraswari's research is still a simple, closed problem, so students only determine whether the given problem can form a triangle (Indraswari et al., 2019). Research examining student failure in solving complex, complex triangle problems based on Islamic integration is still rare. Therefore, this study aims to explore the failure of students of the national madrasah science competition in solving Islamic integrated mathematics problems on triangle material. The results of this study contribute significantly to knowledge related to the various types of failures experienced by students when solving Islamic integrated math problems on the topic of triangles. In addition, teachers can use the results of this study as guidelines in designing learning tools that can minimize student failure in problem-solving.

2. Research Method

2.1 Research Type and Approach

This research used a qualitative approach with multiple case study types. The qualitative approach aims to explore and describe data regarding the failure of national KSM students in solving Islamic-integrated math problems. This multiple case study type of research explores several individuals in situations and conditions at a particular place and time (Gràcia et al., 2020; Tsortanidou et al., 2023).

2.2 Research Subjects

The subjects of this research were students participating in the National KSM. KSM National was attended by 1 best student per province per scientific field. The first-ranked students from the Provincial KSM who became participants in the National KSM consisted of 34 *Madrasah Tsanawiyah* or students aged 13 to 15 years. A total of 5 students answered correctly and completely the triangle problem, while 29 students failed. The subjects selected were 29 students who failed to answer the problem. The subject selection process was carried out based on the following steps.

1. Students who became participants in the National KSM are ranked first in the province KSM.
2. Students failed in solving Islamic integrated math problems on triangle material.
3. Researchers analyzed student failure in solving problems based on the criteria in Table 1.
4. Researchers presented two students as subjects for each criterion found.

2.3 Research Instrument

The instruments in this study consisted of researchers and Islamic integrated mathematics questions on triangle material at the National KSM. The National KSM selection is conducted nationally, simultaneously, and electronically based with multiple choice, short form, and exploration questions. The researcher is the critical instrument (principal) that maps student answers, analyses student failures, describes student failures, and makes conclusions. Islamic integrated mathematics problems on triangle material at the National KSM have been validated by mathematics and mathematics education doctors who have experience preparing questions for national-level mathematics Olympiads/competitions. The problems given are in the form of descriptions so that students' failure to answer can be proven authentically. The problem used in this study is shown in Figure 1.

Ahmad has a rope length k cm where k is the number of verses in surah An-Nazi'at. With the rope, Ahmad makes a triangle whose lengths of the three sides are natural numbers. Find all possible lengths of the sides of the triangle that Ahmad can make.
Note: *congruent triangles are counted by 1*.

Figure 1. Islamic integrated math problem on triangles in National KSM

2.4 Data Collection, Analysis and Validity

Data is collected by giving Islamic integrated math problems on triangle material at the National KSM to prospective subjects. The data collected are the results of the subject's written answers. Data analysis was carried out based on written answers. Techniques used to analyze data include data reduction, categorizing data, presenting data, analyzing findings, and concluding.

Data reduction is done by sorting and selecting correct or incorrect student answers. Data categorization was done by simplifying and discarding parts unrelated to the subject's answers. The categorization was done by grouping the results of the subject's work based on correct and incorrect answers and criteria presented in Table 1. Then, the data was presented descriptively using pictures, tables, and words. Furthermore, the researcher analyzed data related to the subject's answers and then presented them in the discussion section and concluded.

Data validity was carried out with source triangulation. The researcher compared two subjects' data in the same category and then analyzed them. Researchers examined the rubric presented in Table 1.

Table 1. Characteristics of Students' Answers in Solving Islamic Integrated Mathematics Problems on Triangle Materials at the National KSM

Category Failure	Sub Categories	Indicators
Successful (No Failure)	Students can solve the problem correctly and completely	a. Students can integrate Islamic concepts to solve the problem. b. Students use mathematical concepts correctly. c. Students use strategies/procedures wholly and correctly.
Correct process but incomplete	Students can use the correct strategy, but the answer is incomplete	a. Students can integrate Islamic concepts to solve problems. b. Students use mathematical concepts correctly. c. Students use strategies/procedures correctly but need to complete them.
Fail	Students need to integrate Islamic concepts to solve mathematical problems.	a. Students are failed to integrate mathematics in the Quran.
	Students are failed in mathematical problem-solving.	a. Students are failed to establish mathematical principles in the form of triangle properties or triangle inequalities. b. Students are failed in using the concept of congruence to solve problems. c. Students are failed in using relevant strategies to solve problems.

3. Results and Discussion

3.1 Research Type and Approach

The researcher analyzed students' answers to find out what failures were made. The failures experienced by students can be categorized into five failure categories. The five failures consisted of correct but incomplete process failures, failures in integrating Islamic concepts, failures in using mathematical concepts, failures in building mathematical principles, and failures in developing relevant strategies. The categorization of these failures is presented as a chart in Figure 2.

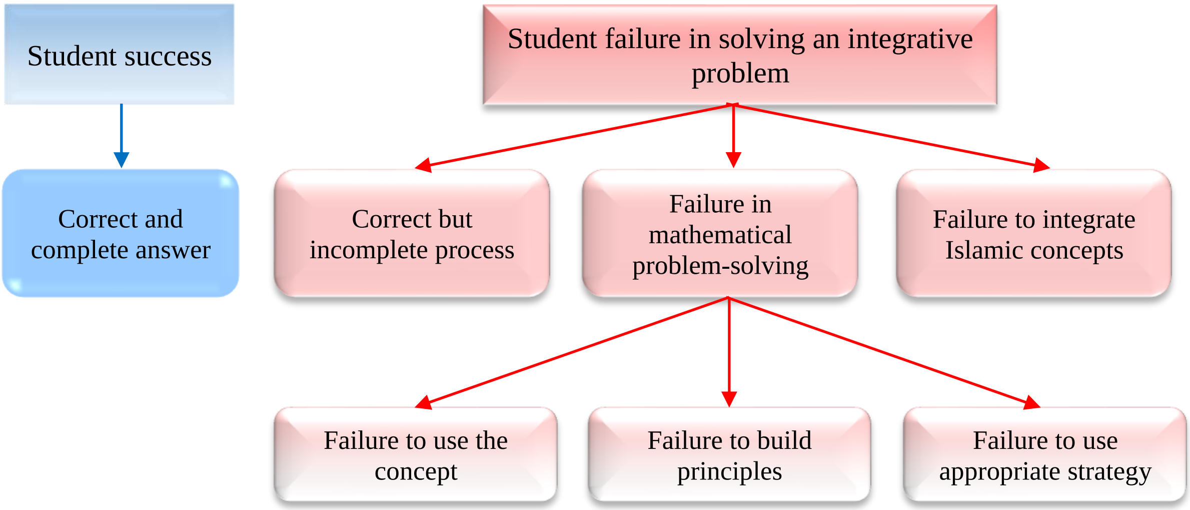


Figure 2. Diagram of student failure categories in solving triangular Islamic integrated problems

After determining the failure categories, the researcher analyzed each subject's answers and grouped them into relevant categories. Then, the researcher looked for the percentage of each failure category in the group. The results of categorization and the percentage of each category are shown in Table 2.

Table 2. Percentage of Failure of Student Answers in Solving Islamic Integrated Mathematics Problems on Triangle Material at the National KSM

Student number	Correct but incomplete process	Failure in Islamic integration	Failure to build mathematical principles	Failure to use mathematical concepts	Use of irrelevant strategies
1		✓	✓	✓	✓
2		✓	✓	✓	✓
3		✓	✓	✓	✓
4			✓	✓	
5			✓	✓	✓
6		✓	✓	✓	✓
7			✓	✓	✓
8			✓		✓
9			✓	✓	✓
10	✓			✓	
11		✓	✓	✓	✓
12		✓	✓	✓	✓
13		✓	✓	✓	✓
14			✓		
15			✓		✓
16			✓	✓	✓
17	✓				
18		✓	✓	✓	✓
19	✓				
20		✓	✓	✓	✓
21				✓	✓

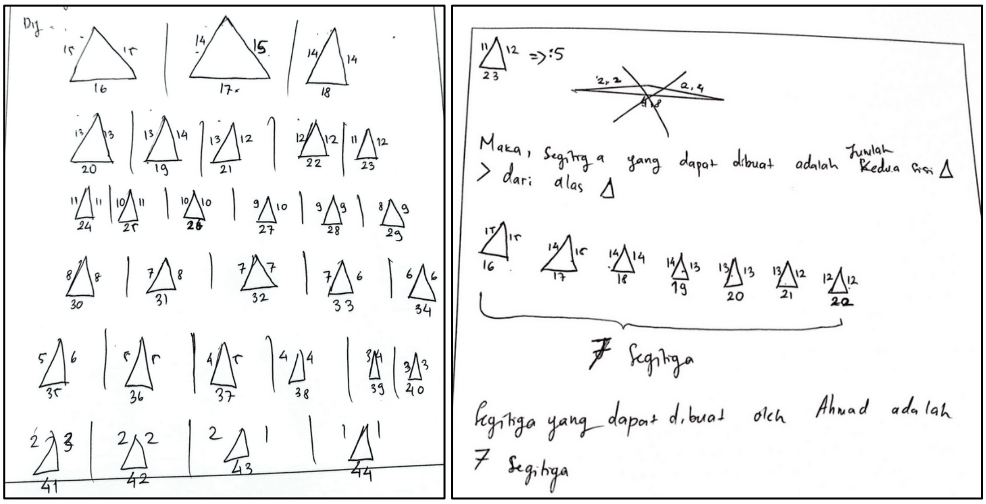
22		✓		✓	✓
23		✓		✓	✓
24		✓			
25		✓			
26			✓	✓	
27		✓			
28			✓	✓	
29			✓		✓
Total	3	14	20	20	19
Percentage	10.4%	48.27%	68.96%	68.96%	65.51%

Table 2 shows that the most common failures made by students are in the types of failures to use mathematical concepts and build mathematical principles. The percentage of these failures reached 68.96%. The slightest failure made failures made by students were when mathematics was integrated into the Quran 48.27%. The correct but incomplete process is one of the five failure categories. The percentage of student answers in this category is the slightest failure, which is 10.4%. The following description explains the category of each failure, accompanied by the explanation of two subjects in each category.

3.1.1. Failure in the Correct and Complete Process

a. The 10th subject (S10)

S10 failed in the correct and complete process because S10 gave the correct but incomplete process. S10's failure is shown in the answer he wrote. S10's answer is shown in Figure 3.



(a) (b)

Figure 3. S10's answer: (a) Answer when S10 elaborates; (b) Answer when S10 makes a conclusion

Based on Figure 3a, S10 elaborated on the various possibilities to form a triangle with a total side length 46. The way S10 elaborated, starting from making the first triangle with the size of one side 16, the second triangle with the size of one side 17, the third triangle with the length of one side 18, and so on until the triangle with the length of one side 44.

In Figure 3b, S10 wrote, *"Then, the triangle that can be made is the sum of the two sides of the triangle > the base of the triangle."* The statement is evidence that S10 understands the conditions for forming a triangle, namely that the sum of the lengths of the two sides of the triangle must be more than the length of the other side. Based on the 29 triangles described in Figure 3a, S10 only listed 7 triangles that fulfill the conditions for forming a triangle.

The answer shown by S10 by listing 7 triangles is correct. However, the answer still needs to be completed. S10 has not been able to describe all the possible triangles that can be formed. In Figure 3a, S10 only listed 29 triangles. Thus, S10 can be categorized into correct failure, which is using the proper process and finding the correct but incomplete answer.

b. The 17th subject (S17)

S17 failed in the correct and complete process because S17 showed the correct but incomplete process. S17's failure is shown in the answer she wrote. S17's answer is shown in Figure 4.

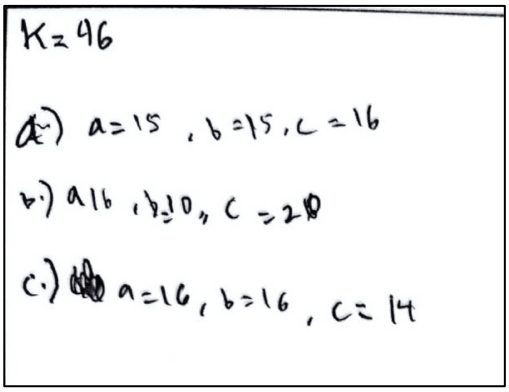


Figure 4. S17's answer

Based on Picture 4, S17 has determined the value K=46. S17 has succeeded in finding the K value correctly. Then, S17 writes three triangles whose side values add up to 46. The first triangle is written with sides a=15, b=15, and c=10. The second triangle is written with sides a=16, b=10, and c=20. The third triangle is written with sides a=16, b=16, and c=14.

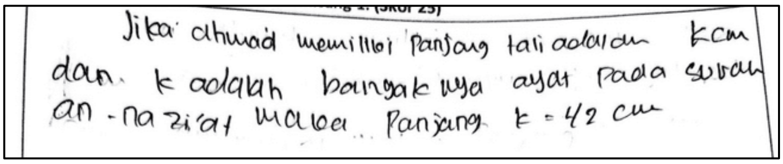
Based on the three triangles written in the answer, S17 has understood the principle of triangle inequality. This is proven by all the triangles found in S17 that fulfill the principle of the triangle inequality. Apart from that, the S17 also seems to understand the concept of congruence. This is proven by S17, which only writes the triangle once for each triangle. There are no repetitions of sides of the same value in each triangle.

However, where the S17 failed was seen in its ability to decipher answers. Of the many possible triangles that could be formed, S17 could only find three triangles. There are still other triangles that still need to be revealed. Thus, S17 can be categorized as a correct failure using the proper procedure, but the answer needs to be completed.

3.1.2. Failure in Mathematical Integration Facts in the Quran

a. The 1st Subject (S1)

S1 experienced failure in the facts of mathematical integration in the Quran. S1's failure is shown in the answer he wrote. S1's answer is shown in Picture 5.



Picture 5. S1's answer

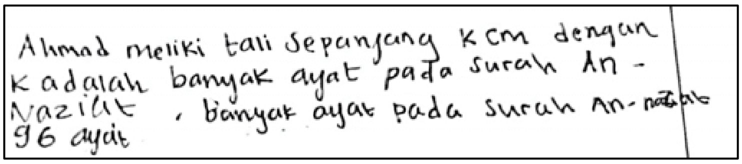
Based on Picture 5, S1 wrote, "If Ahmad has a rope length of k cm and k is the number of verses in Surah An-Nazi'at, then the length of k = 42 cm". This shows that S1 has taken the length of the rope as k, whose value is equivalent to the number of verses in Surah An-Nazi'at, namely 42. In other words, S1 has linked the information on the problem with the facts he knows about the many verses in Surah An-Nazi'at.

The error made by S1 occurred in the facts presented. S1 considers that the number of verses in Surah An-Nazi'at is 42. Surah An-Nazi'at is the 79th surah with 46 verses. S1 was wrong in conveying the facts regarding the number of verses in the An-Nazi'at letter, which should consist of 46 verses.

S1's error in integrating facts impacts S1's interpretation of the information provided. This error makes S1 assume the length of the rope symbolized by k is 42 cm. Even though the length of the rope should be 46 cm. Thus, S1's failure to understand mathematical integration in the Al-Quran impacts S1's overall answer, which is confirmed to be wrong.

b. The 13th Subject (S13)

S13 experienced failure in the facts of mathematical integration in the Koran. The failure of S13 is shown in the answer he wrote. S13's answer is shown in Picture 6.


Ahmad meliki tali sepanjang k cm dengan
k adalah banyak ayat pada surah An -
Nazi'at , banyak ayat pada surah An-nazi'at
96 ayat

Picture **6**. S13's answer

Based on Picture 6, S13 wrote, "*Ahmad has a rope of length k cm where k is the number of verses in Surah An-Nazi'at, the number of verses in Surah An-Nazi'at is 96.*" This shows that S13 took the length of the rope as k, whose value is equivalent to the number of verses in Surah An-Nazi'at, namely 96. S1 has linked the information on the problem with the facts he knows about many verses in Surah An-Nazi'at.

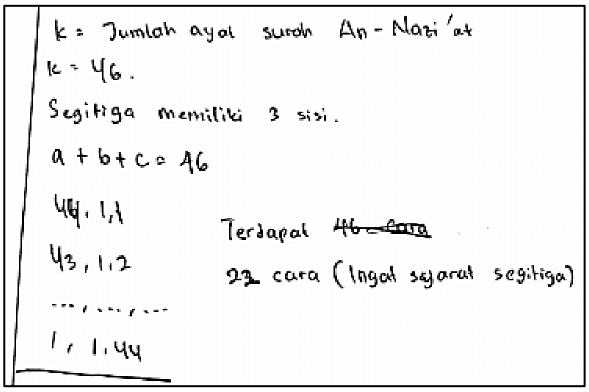
The error made by S13 occurred in the facts presented. S13 considers that the number of verses in Surah An-Nazi'at is 96. Surah An-Nazi'at is the 79th surah with 46 verses. In other words, S13 was wrong in conveying the facts regarding the many verses in the An-Nazi'at letter.

S13's error in integrating the facts of the 46 verses in Surah An-Nazi'at impacted S13's interpretation of the information provided. This error made S13 think the length of the rope was 96. Even though the length of the rope should be 46 cm. Thus, S13's failure to understand the facts of mathematical integration in the Al-Quran impacts S13's answer, which is confirmed to be wrong.

3.1.3. Failure of Students in Developing Mathematical Principles in the form of Triangle Properties or Triangle Inequalities

a. The 4th Subject (S4)

S4 experienced failure in establishing mathematical principles. S4's failure is shown in the answer he wrote. Answer S4 is shown in Picture 7.



Picture 7. S4’s answer

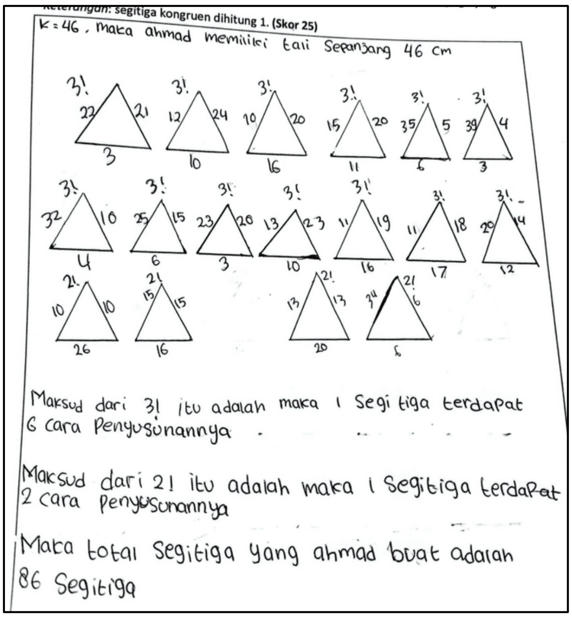
Picture 7 shows S4 stating that a triangle consists of 3 sides, for example, sides a, b, and c. S4 states that the sum of the three sides will be 46, which a+b+c=46 indicates. S4 can link integration facts with information obtained from the problem.

Next, S4 determines the values of sides a, b, and c that satisfy $a + b + c = 46$. For the first triangle, S4 wrote "44, 1, 1," which means side a is worth 44, side b is worth 1, and side c is worth 1. For the second triangle, S4 wrote "43, 1, 2," which means side a is worth 43, side b has a value of 1, and side c has a value of 2. The sum of the values a, b, c, added together produces 46. S4 writes "..., ..., ..." and "1, 1, 44," which means the process continues until we get side $a = 1$, side $b = 1$, and side $c = 44$.

Then S4 wrote, "There are 22 ways (remember the triangle requirement)". S4 does not detail the terms of the triangle in question, so the terms of the triangle written in S4 still need to be clarified. Also, writing S4 on a triangle with side lengths "44, 1, 1" does not meet the triangle requirements. This is because the sum of the lengths of both sides is no more than the length of the other side (1+1<44). Thus, S4 could have used the principle of triangle inequality.

b. The 7th Subject (S7)

S7 needed to have established mathematical principles. The failure of the S7 is shown in the answer it wrote. S7's answer is shown in Picture 8.



Picture 8. S7’s answer

Based on Picture 8, S7 draws 17 triangles whose side lengths vary between triangles. Then S7 groups the seventeen triangles into two groups, marked with 3! and 2!. S7 wrote, "The meaning of 3! That is, 1 triangle has 6 ways of arranging it." S7 also wrote, "*The meaning of 2! That is, 1 triangle has 2 ways of arranging it.*"

For the first group, marked S7 with "3!" each triangle it makes is the same. This similarity can be seen from the fact that each side that forms a triangle does not have the same length. For example, a triangle with side lengths of 22; 21; 3, 12; 24; 10, 32; 10; 4 and others. The same thing can also be seen from the fact that adding the three sides of a triangle always produces 46. For example, 22+21+3=46, 24+10+32=46, 32+10+4=46, and others. The first group can be categorized as arbitrary triangles because each triangle has no sides of the same length.

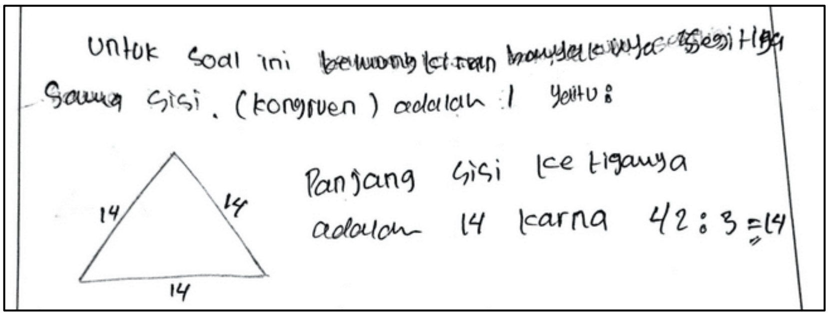
The second group is marked S7 with "2!". This group has the same characteristics as each triangle it creates. This similarity is characterized by each triangle having two sides of the same length. For example, a triangle with side length 10; 10; 26, 15; 15; 16, 13; 13; 20, and others. In addition, the sum of the three sides always produces 46. The second group can be categorized as equilateral triangles.

If you look at Picture 8, S7 writes several sides of the triangle, namely 12, 10, 24; 35, 5, 6; and 39, 4, 3. These three triangles do not satisfy the triangle inequality. This is because the sum of the lengths of the two sides is not more than the length of the other side. For example, in the triangles 12, 10, and 24, the addition of 12 and 10 produces 22, less than 24. If this condition occurs, it will not form a triangle. Thus, S7 failed because it needed to understand the principle of triangle inequality.

3.1.4. Students' Failure to Use the Concepts of Congruence and Circumference to Solve Problems

a. The 1st Subject (S1)

Students' Failure to Use the Concepts of Congruence and Circumference to Solve Problems.

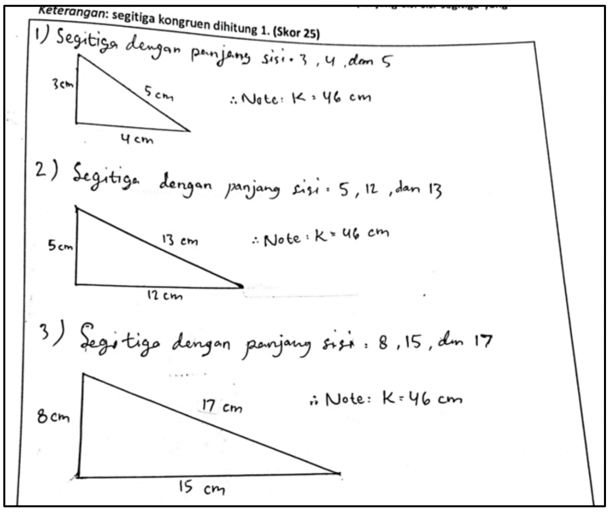


Picture 9. S1's answer

Based on Picture 9, S1 wrote, "For this problem, the possible number of equilateral (congruent) triangles is 1". Then S1 wrote, "The length of the third side is 14 *because 42 : 3 = 14*". This article shows that S1 considers congruence to occur in equilateral triangles. This is confirmed by S1 finding that the side length of an equilateral triangle is 14 units. In other words, S1 considers congruence in triangles to only occur in triangles with the same sides. S1 could have used congruent concepts to solve problems.

b. The 16th Subject (S16)

S16 could have used mathematical concepts. The S16 failure is shown in the written answer. Answer S16 is shown in Picture 10.



Picture 10. S16's answer

Picture 10 shows that S16 has created three triangles. The first triangle has sides 3 cm, 4 cm, and 5 cm. The second triangle has sides 5 cm, 12 cm, and 13 cm. Meanwhile, the third triangle has 8 cm, 15 cm, and 17 cm sides. The three triangles created by S16 have the same thing: the right triangles. In addition, the lengths of the sides made by S16 in the three triangles are Pythagorean triples.

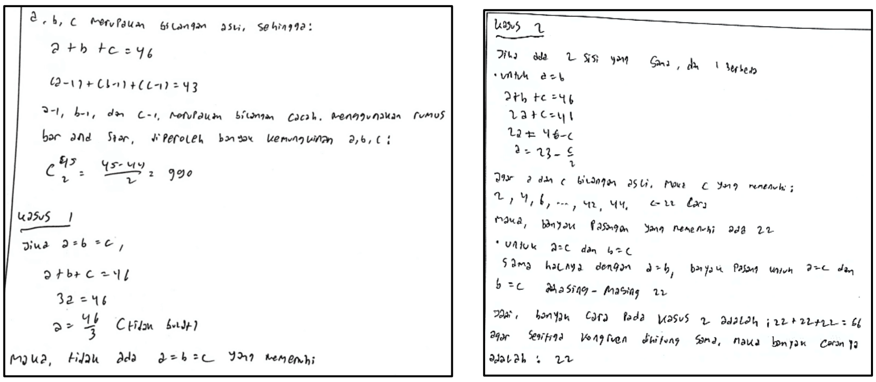
Based on this, S16 understands that a triangle can be formed from a right triangle with side lengths that fulfil the Pythagorean triple. S16 does not list any other triangle shapes other than right triangles. S16 understands that a triangle can only be formed from a right triangle with a Pythagorean triple. S16's lack of understanding of the triangle concept made S16 fail to solve the problem given.

Furthermore, the three triangles formed by S16 have different triangle perimeters. The first triangle has a perimeter of 12 cm, the second triangle has a perimeter of 30 cm, and the third triangle has a perimeter of 40 cm. The three triangles formed do not have a perimeter of 46 cm. S16 has succeeded in identifying the circumference asked about in the problem, namely 46. However, the three triangles formed by S16 do not have a perimeter of 46. S16 failed to understand the circumference of a triangle, which caused him to fail in solving the problem.

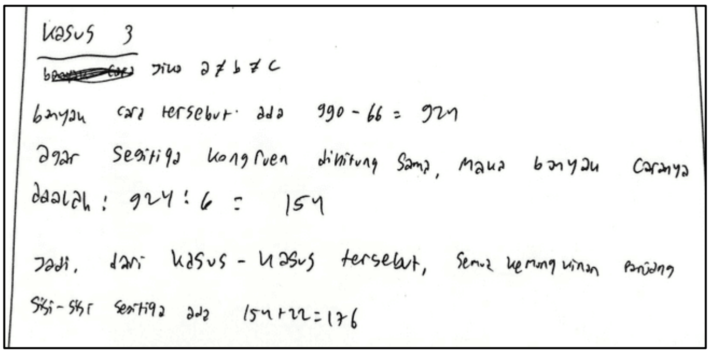
3.1.5. Students Use Less Relevant Strategies to Solve Problems

a. The 15th Subject (S15)

S15 experienced failure in using less relevant strategies. The failure of the S15 is shown in the answer he wrote. Answer S15 is shown in Picture 11.



(a) (b)



(c)

Picture 11. S15's Answer: (a) When determining the number of possibilities and explaining case 1; (b) When explaining case 2; (c) When explaining case 3 and drawing conclusions

Based on Picture 11a, S15 calculates the number of possible triangles that can be formed using the bar and star formula. S15 calculates the combination $45C_2$, which produces 990. There are 990 possible ways to create a triangle if the length of all sides is 46 cm. Next, S15 sees many possible equilateral triangles formed in the first case. S15 assumes side a = side b = side c and relates it to the length of side $a + b + c = 46$. As a result, S15 did not find an integer for 46 divided by 3. S15 concluded that it was impossible to form an equilateral triangle if the sum of all the sides was 46.

Based on Picture 11b, S15 creates a second case for isosceles triangles. S15 assumes that $a = b$, which means that side a and side b have the same length. Then, S15 uses the example $a = b$ and relates it to the side length $a + b + c = 46$. As a result, S15 finds that $a = 23 - c/2$, which means the value of c must always be an even number between 2 and 44 so that the value of a can be defined as integers. Thus, S15 finds 22 ways to satisfy the value c. The exact process is also carried out in S15 by assuming $b = c$ and $a = c$ so that from both of them, we get 44 ways. Thus, S15 found 66 ways to form an isosceles triangle with 22 ways to create a congruent triangle.

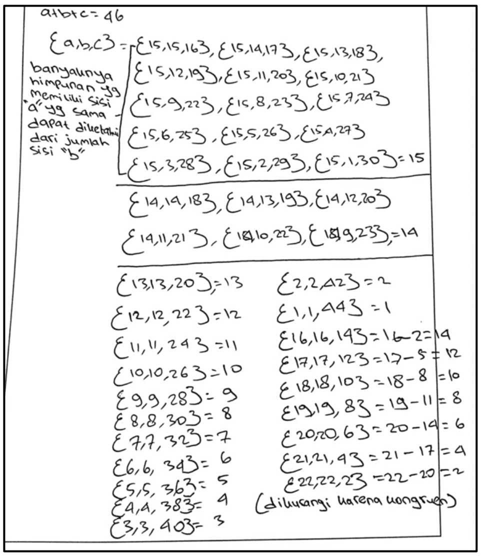
Based on Picture 11c, S15 constructs a third case dedicated to arbitrary triangles. S15 assumes that $a \neq b \neq c$, which means that side a, side b, and side c have different lengths. S15 uses the bar and star formula results, case 1 and case 2, to find case 3. The bar and star formula produces 990 ways for all possible triangles, case 1 produces 0 ways for isosceles triangles, and case 2 produces 66 ways for an equilateral triangle. Then S15 operates 990 – 0 – 66, which produces 924. The meaning of 924 is all possible arbitrary triangle shapes.

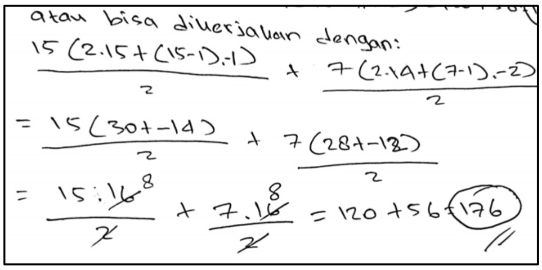
Since the rules of the problem require that congruent triangles be considered equal to one, 924 divided by 6 gives 154, which means that an arbitrary triangle can be formed in many possible ways. There are many ways to create a triangle with three sides of 46, namely by adding 0 ways, 22 ways, and 154 ways to get 176 ways. Thus, S15 found that there are 176 ways to arrange the triangle.

Based on the previous description, which is reinforced by Picture 9, it shows that S15 uses enumeration rules to solve the problem. This is a mistake because enumeration rules help see how things are formed. The solution using the enumeration rule strategy does not involve the principle of triangle inequality. Even though S15 has used the concept of congruence and explained the concept using enumeration rules, the resulting answer must be corrected. This is because S15 does not use the principle of triangle inequality. Thus, S15 failed because it used an irrelevant strategy.

b. The 8th Subject (S8)

S8 could have used less relevant strategies. The failure of the S8 is shown in the answer it wrote. S8's answer is shown in Picture 12.





(a) (b)

Picture 12. S8's Answer: (a) When describing the various possible sides of a triangle that can be created; (b) When calculating the number of ways that can be made

Based on Picture 12a, S8 describes various possible side lengths a, b, and c of a triangle that can satisfy $a + b + c = 46$. S8 starts by looking at the possibility of side $a = 15$, side $a = 14$, and so on until side $a = 1$. After that, S8 also looks at the possibility of side a being worth 16, side a being worth 17, and so on until side a is worth 22. Side b and side c adjust side a. S8 then counts the number of ways for each side of a. There are 15 ways for side $a = 15$, 14 ways for side $a = 14$, 13 ways for side $a = 13$, and so on until 1 way for side $a = 1$. Then there are 14 ways for side $a = 16$, 12 ways for side $a = 17$, 10 ways for side $a = 16$, and so on, up to 2 ways for side $a = 22$.

In Picture 12b, S8 uses the concept of arithmetic series to add up all the methods it obtains. S8 carried out this concept in two groups. The first group for $a = 15$ to $a = 1$ has the number of ways to form the sequence 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1. While the second group is carried out on $a = 16$ to $a = 22$, the number of ways to form a sequence is 14, 12, 10, 8, 6, 4, 2. S8 uses the concept of arithmetic series on sequences in the first and second groups to find the number of ways to arrange triangles, namely 176.

Based on the previous description, which is reinforced by Picture 12, it shows that S8 uses a strategy of describing all possibilities followed by an arithmetic series. This is a mistake because this strategy is only proper when considering the number of ways. Even though S8 used the concept of congruence when explaining, the resulting answer needed to be corrected. This is because this strategy does not use the principle of triangle inequality. Thus, S8 failed because it used an irrelevant strategy.

3.2 Discussions

Researchers analyzed students' answers to find out what failures they had made. The failures experienced by students can be categorized into five categories of failure. The five failures consisted of failure in correct but incomplete processes, failure to integrate Islamic concepts, failure to use mathematical concepts, failure to develop mathematical principles, and failure to develop relevant strategies. The failure categorization is presented in chart form in Picture 2.

3.2.1. Failure in Complete and Correct Process

Failure in the correct but incomplete process occurs when students can integrate Islamic concepts, use the concepts of congruence and perimeter of triangles, build the principle of inequality of triangles, and use relevant strategies but need help to answer the problem given thoroughly. Students can use the correct concepts, principles, and strategy, but the answers found need to be completed. Even though the answer the student found was accurate, the student was classified as failing because the answer was incomplete. This is due to students' need for more skill in describing all the existing possibilities.

If viewed from an analytical thinking perspective, this failure was caused by students needing to be more optimal at the differentiating stage. Weak differentiation in analytical thinking makes it difficult for students to see all possible answers (Anderson & Krathwohl, 2001). This aligns with Alghar (2022) and Azizah et al. (2021), that analytical thinking skills in the differentiating section make the answers students find incomplete when solving problems. Apart from that, student failure can also be viewed from critical thinking. When students cannot identify various possible assumptions, they experience issues with advanced classification in critical thinking (Ennis, 2011). This is in line with Garrison, Anderson, and Archer (2001) that students' difficulties in evaluating and seeing various alternative solutions indicate that students are experiencing problems in thinking and reasoning critically.

3.2.2. Failure in Mathematical Integration Facts in the Quran

Student failure in mathematics integration facts in the Al-Quran occurs when students need help to answer Islamic integration questions. In this research, students considered the An-Nazi'at verse the 42nd or 96th. The An-Nazi'at letter is in 46th place. This indicates that students experience failure in facts related to the order of letters in the Al-Quran. This failure was caused by students needing to learn the order of the An-Nazi'at letters.

When viewed from the cognitive dimension, students experience difficulties in the remembering section (Anderson & Krathwohl, 2001). Students' inability to remember the sequence of An-Nazi'at letters causes them to make mistakes in subsequent procedures when solving problems. This aligns with research by Himmah et al. (2019) and Prismana et al. (2018) that remembering is the main foundation for solving questions requiring facts. When viewed from mathematical objects, students experience failure in factual knowledge. Students need to learn fundamental mathematical elements, such as the meaning of symbols, numbers, signs, and pictures. This is in line with Novferma (2016) that factual knowledge in mathematics is the basic foundation for students to be able to solve problems.

3.2.3. Student Failure to Use Concepts to Solve Problems

Failure to use concepts is shown when students cannot correctly use the concepts of congruence and perimeter of a triangle. In the idea of congruence, students assume that three right triangles with different side lengths for each triangle are congruent. Students need to see that a triangle can be congruent to itself three times. Meanwhile, failure to understand the perimeter of a triangle occurs when students determine a value for the perimeter of a triangle that does not correspond to the length of the sides of the triangle.

This failure shows that students need to be aware of concept errors. When viewed from metacognitive studies, these students experience metacognitive blindness. This happens when a student's answer is incorrect, and he is unaware of an error in his work. In line with Goos (2002) and Huda et al. (2018), when students do not detect errors and ignore the mistakes they make, they experience metacognitive blindness.

Apart from that, students also experience problematic met-before (Rofiki, 2023). Met-before occurs when students understand congruence applies to two or more triangles. Students need to know that the concept of congruence can also happen in a triangle concerning itself. This is in line with research by de Lima & Tall (2006), which states that old ideas used by students when solving new problems can cause failure in solving problems. Thus, the failure experienced by students in understanding the concept was due to the met-before they experienced.

Furthermore, students' failure in the concept of the perimeter of a triangle was due to construction holes. Students discovered the perimeter of a triangle. However, all the triangles that are formed contain Pythagorean triples. However, not all triangles have to contain sides with Pythagorean triples. This indicates that students experience a cognitive hole regarding the concept of triangles. Subanji (2015) explains that students who experience cognitive holes in triangle problems assume that triangles must be right-angled with Pythagorean triples. This cognitive hole occurs because students need help understanding the concept of triangles and the conditions for forming triangles (Subanji, 2016b).

3.2.4. Students' Failure to Develop Principles to Solve Problems

Students need to improve in building principles when writing the sides of a triangle that do not fulfil the principle of triangle inequality. Some students wrote triangles with 44, 1, and 1 side lengths. This indicates that students need to understand the principle of inequality of triangles. This lack of understanding is a symptom of a construction hole in his knowledge.

This is in line with what Subanji (2015) explained: in constructing the concept of a triangle, students experience holes in the conditions for forming a triangle. Students need to pay more attention to the conditions for forming a triangle. This neglect causes students to assume that triangles can be formed by any side size (Subanji, 2016b). Thus, the failure experienced by students in building principles is due to construction holes in students' understanding.

3.2.5. Students' Failure to Use Relevant Strategies to Solve Problems

Failure to use relevant strategies is demonstrated by students using inappropriate procedures to solve problems. Based on the answer sheet, some students used combinatorial and arithmetic sequences to solve problems. Even though the strategy is mathematical, more is needed to solve the given problem. This is because the strategy is not the strategy that should be used to solve the problem.

If viewed from a problem-solving perspective, this failure was caused by students using unfamiliar problem-solving strategies (Kurniawan et al., 2018). Students also do not understand the context of the problem given, so they do not know problem-solving strategies (Kurniawan et al., 2018; Subanji, 2016a). Researchers suspect that students have pseudo-failures that cause them to fail to use relevant strategies. This suspicion is caused by students using mathematical methods that are not appropriate to the context of the problem. However, researchers needed more interviews and think-aloud to dig deeper into the alleged pseudo-thinking. For further research, the researcher suggests that the following study use interviews and think-aloud to dissect students' alleged pseudo-thinking in solving triangle problems.

4 Conclusion

This study reports that the characteristics of students' failure in solving Islamic integrated mathematics problems are classified into five categories. First, failure to provide a correct and complete process. This failure occurs because students need help finding all the correct answers. Second, more Islamic values must be integrated to solve mathematics problems. This failure occurred because students needed to gain knowledge about Islamic concepts that could be used to solve problems. Third, failure to use mathematical concepts. The concept students cause this failure use that is inappropriate for solving the problem. Fourth, we need to establish mathematical principles. This failure occurred because the mathematical principles used by students were not comprehensive. Fifth, failure to implement relevant strategies. This failure was caused by students needing to use appropriate methods to solve the problems given.

This research can be a gateway to open other relevant research. It is imperative to conduct future research to refine the types of failures discovered. Further study can provide scaffolding for each type of failure experienced by students. Moreover, the subsequent research can include in-depth interviews to examine the pseudo-false thinking process in solving Islamic integrated mathematics problems.

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