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Analysis of Analogical Reasoning in Students with High Emotional Intelligence in Solving Geometry Problems

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Abstract

This study aims to analyze the analogical reasoning of students with high emotional intelligence in solving geometry problems. The research employed a qualitative descriptive approach, conducted at SMP Negeri 9 Tasikmalaya with one eighth-grade student selected based on an emotional intelligence questionnaire. Data were collected through an analogical reasoning test on geometry and in-depth interviews, then analyzed using the Miles and Huberman model, including data reduction, data display, and conclusion drawing. The results revealed that the student successfully passed all stages of analogical reasoning, namely encoding, inferring, mapping, and applying. At the encoding stage, the student identified essential problem elements; the inferring stage showed the ability to recognize structural similarities using the Pythagorean theorem; the mapping stage highlighted the transfer of strategies between source and target problems; and the applying stage emphasized the correct application of area formulas to reach solutions. This research contributes to the development of understanding regarding the relationship between emotional intelligence and mathematical reasoning, and provides a reference for strengthening instructional strategies that support both cognitive and affective aspects of students.

Keywords: analogical reasoning, emotional intelligence, geometry, problem solving

Abstrak

Penelitian ini bertujuan untuk menganalisis penalaran analogi siswa dengan kecerdasan emosional tinggi dalam menyelesaikan masalah geometri. Penelitian menggunakan pendekatan kualitatif dengan jenis deskriptif, dilaksanakan di SMP Negeri 9 Tasikmalaya dengan subjek seorang siswa kelas VIII yang dipilih berdasarkan hasil angket kecerdasan emosional. Data dikumpulkan melalui tes penalaran analogi berbasis geometri dan wawancara mendalam, kemudian dianalisis dengan model Miles dan Huberman yang meliputi reduksi data, penyajian data, dan penarikan kesimpulan. Hasil penelitian menunjukkan bahwa siswa mampu melalui setiap tahapan penalaran analogi, yaitu encoding, inferring, mapping, dan applying. Pada tahap encoding, siswa dapat mengidentifikasi unsur penting dalam soal; tahap inferring memperlihatkan keberhasilan menemukan kesamaan pola melalui teorema Pythagoras; tahap mapping menunjukkan keterampilan memindahkan strategi dari masalah sumber ke target; dan tahap applying menegaskan kemampuan menerapkan rumus luas bangun secara runtut hingga menemukan solusi. Penelitian ini berkontribusi pada pengembangan pemahaman tentang keterkaitan kecerdasan emosional dan penalaran matematis, sekaligus menjadi rujukan untuk penguatan strategi pembelajaran yang mendukung aspek kognitif dan afektif siswa.

Kata kunci: penalaran analogi, kecerdasan emosional, geometri, penyelesaian masalah

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INTRODUCTION

Mathematics is one of the disciplines that plays an important role in developing analytical, critical, logical, and systematic thinking skills (Alghar et al., 2024; Kriswandani et al., 2022; O'Keeffe & Paige, 2021; Rifqi et al., 2021). Students are not only expected to memorize procedures but also to understand concepts and apply them to other problems. One form of reasoning that plays an important role is analogical reasoning (Innayah et al., 2020). Analogical reasoning is defined as the ability to connect the structure of knowledge from a familiar problem to a new problem that has similarities (English, 2004; Vendetti et al., 2015). Analogical reasoning is very important because it forms the basis for developing conceptual understanding (Ramdhani et al., 2019; Vendetti et al., 2015). However, the

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reality on the ground shows that many students still struggle to transfer knowledge from one context to another (Rahmawati & Pala, 2017).

These difficulties are evident when students are asked to work on non-routine problems that require the ability to generalize concepts. Many students can solve routine problems presented by teachers, but fail when the problems are slightly modified or presented in a different form (Ardani & Ningtiyas, 2017; Wardhani et al., 2016). This condition indicates that most students are only oriented toward formulas or procedural steps, without truly understanding the structure of the problem (Ng & Chew, 2023). However, understanding the structure of the problem is a prerequisite for analogical reasoning. The obstacles that arise often occur at the inferring and mapping stages, when students must conclude the relationship and map the similarities between the source problem and the target problem (Kristayulita et al., 2020; Ramdhani et al., 2019).

Analogical reasoning in mathematics is influenced not only by cognitive aspects, but also by affective aspects that influence students' mindsets (Tuti et al., 2018). Mood and emotional regulation skills play a significant role in students' resilience when tackling difficult problems. Students with positive emotions tend to be more persistent, diligent, and confident in solving mathematical problems (Goleman, 2005; Tuti et al., 2018). Conversely, students with low emotional intelligence often give up quickly when faced with difficulties (Parker et al., 2004). Previous research has also shown a significant relationship between emotional intelligence and mathematics learning achievement (Eva & Kusrini, 2016).

Geometry is a branch of mathematics that has the potential to train students' analogical reasoning (Ramdhani et al., 2019). Geometry learning requires students to understand the relationships between shapes, visualize figures, and connect related concepts (Midgett & Eddins, 2001; Özerem, 2012). Geometric concepts such as plane figures are often used to sharpen students' ability to connect simple situations to complex ones (Aguilera, 2023). However, students often experience misconceptions in geometry, making it difficult for them to transfer knowledge to new contexts (Özerem, 2012; Sudihartinih, 2021). Thus, geometry becomes a relevant context for examining analogical reasoning.

The stages of analogical reasoning consist of encoding, inferring, mapping, and applying. Each stage requires different skills, ranging from identifying important information, drawing conclusions, mapping structural similarities, and applying solutions to new problems (English, 2004; Vendetti et al., 2015). Students with strong analogical reasoning skills can accurately connect information from the source problem to the target problem. However, students who struggle tend to fail to generalize solution strategies, making it difficult for them to solve problems correctly (Amir, 2023; Kristayulita et al., 2020). Therefore, a thorough analysis of the stages of analogical reasoning is necessary to understand students' thinking profiles.

Although many studies have discussed the relationship between emotional intelligence and mathematical achievement, studies that specifically highlight the analogical reasoning of students with high emotional intelligence are still rare. Previous studies have only compared students with high and low emotional intelligence without describing the profile of their analogical thinking stages (Nwadinigwe & Azuka-Obieke, 2012; Ramdhani, 2021). However, an in-depth analysis of students with high emotional intelligence is important to identify their potential. This study aims to fill this gap by describing how students with high emotional intelligence use analogical reasoning to solve geometry problems.

Furthermore, the study of analogical reasoning in the context of geometry is in line with the national curriculum requirements that emphasize the mastery of critical, creative, communicative, and collaborative thinking skills (Permendikbud, 2013). Geometry as a core subject provides significant opportunities for students to connect mathematical ideas in various real-life situations (As'ari et al., 2019; Siregar & Marsigit, 2015). Through analogical reasoning, students can better understand the relationships between concepts and develop flexible problem-solving strategies (Rosyidi, 2024). Therefore, analyzing the analogical reasoning of students with high emotional intelligence is very important.

Based on the above description, this study aims to analyze the analogical reasoning of students with high emotional intelligence in solving geometry problems. This study focuses on the encoding, inferring, mapping, and applying stages in the context of plane geometry problems. The results of this study are expected to enrich the literature on emotional intelligence and students' reasoning abilities. Additionally, the findings of this study can be used as a reference for teachers in designing learning that involves cognitive and affective aspects in a balanced manner (Kristayulita et al., 2020; Rahmawati & Pala, 2017). Thus, this study is not only useful theoretically but also has practical implications for mathematics education in Indonesia.

METHODS

This study uses a qualitative approach with a descriptive research type. The qualitative approach was chosen because it is in line with the research objective, which is to describe the stages of students' analogical reasoning in solving geometry problems. The research focuses on the stages of analogical reasoning of students with high emotional intelligence, which include encoding, inferring, mapping, and applying. The research was conducted at SMP Negeri 9 Tasikmalaya in the eighth grade during the 2020/2021 academic year. The research subjects were selected using purposive sampling, namely students with high emotional intelligence. These subjects were categorized based on the results of a validated questionnaire.

The research data were collected through tests, interviews, field notes, and documentation. Tests were used to trace the stages of analogical reasoning, while interviews were used to explore information that was not apparent in written answers. In addition, field notes and documentation were used as supporting data to strengthen the validity of the research findings. The main instrument of this research was the researcher himself, who was directly involved in the entire research process. The secondary instruments were analogy reasoning test questions and semi-structured interview guidelines. The

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problems used to elicit analogy reasoning were source problems and target problems, as shown in Figure 1.

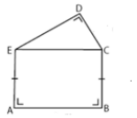
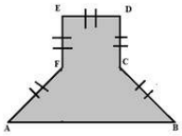
Masalah Sumber	Masalah Target
Bangun ABCE seperti gambar dibawah ini memiliki panjang 15 cm dan memiliki lebar 5 kurang dari panjangnya. Bangun CDE memiliki alas 9 cm dan siku-siku di D. Hitunglah luas dari bangun datar ABCDE ! 	Perhatikan gambar di bawah ini !  Bangun ABCF memiliki sisi sejajar dengan ukuran terpanjangnya 39 cm sedangkan sisi yang lainnya memiliki ukuran sama panjang yaitu 15 cm. Hitunglah luas bangun ABCDEF !

Figure 1. Source and target problems used to elicit students' analogical reasoning

The research data was analyzed using the Miles et al. (2014) model, which includes data reduction, data presentation, conclusion drawing, and verification. This research procedure was carried out in several stages, namely (1) preparation of instruments and selection of subjects, (2) administration of tests and interviews, (3) processing of test and interview results, and (4) in-depth analysis according to the stages of analogical reasoning. The research data analysis was conducted comprehensively to obtain a complete picture of the analogical reasoning of students with high emotional intelligence.

RESULT AND DISCUSSION

Encoding stage

Figure 2 shows the results of subject S9's work at the encoding stage in solving the source and target problems. It can be seen that the students wrote down the known and unknown elements completely in both problems.

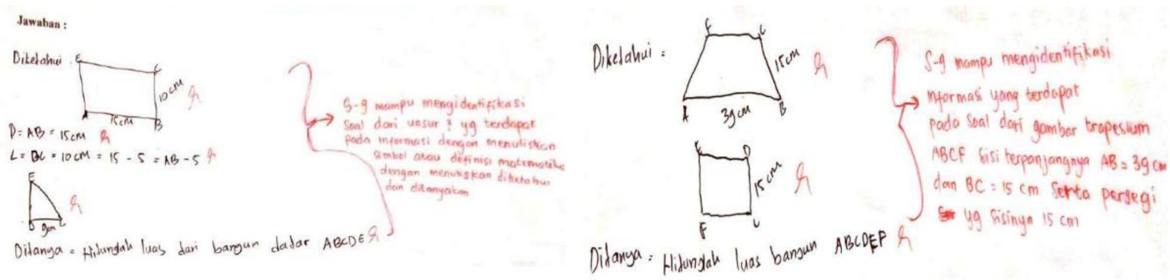


Figure 2. S9 test results on the source problem and target problem in the encoding stage

These results were reinforced through interviews between the researcher and the subjects, in which the students were able to accurately explain the elements in the questions.

P: Okay, now I want to ask you a question. What is known in the question?

S9: The flat shapes with angles ABCE and ABCF, ma'am.

P: What shape is ABCE? What about ABCF?

S9: ABCE is a rectangle, and ABCF is a trapezoid.

Based on the test results and interviews, S9 students are able to clearly understand the structure of the questions. S9 can identify the elements of flat shapes in both the source and target problems without confusion. The accuracy of S9 in identifying information demonstrates systematic thinking skills. S9 is also able to distinguish important information and eliminate irrelevant details in both problems. This consistency between the results of their work and their verbal responses during the interview indicates that the encoding stage has been effectively fulfilled by S9.

These results indicate that emotional intelligence supports student success in the encoding stage. Rosida (2015) asserts that students' focus on understanding test questions is influenced by emotional stability. This finding is consistent with Faizi (2018), who states that emotional factors make students more careful and motivated in identifying mathematical elements. Furthermore, English (2004) emphasizes that encoding is the main foundation of analogical reasoning in mathematics. This is in line with Amir-Mofidi et al. (2012) and Tuti et al. (2018), who found that students who are better at managing their emotions tend to be more successful in understanding the initial information in mathematical analogies. The findings of this study can also be compared with the study by Holyoak & Morrison (2005), which states that the success of analogical reasoning begins with the ability to accurately represent information at the encoding stage. Meanwhile, Baltazar (2022) mentions that students who are able to regulate their emotions are more consistent in problem solving and analytical thinking. Thus, it can be concluded that the encoding stage is influenced by a combination of cognitive and emotional factors in students.

Inferring stage

Figure 3 shows the results of S9's work at the inferring stage when solving the source problem and the target problem. It can be seen that S9 is able to find similarities between the two problems through the application of the Pythagorean theorem.

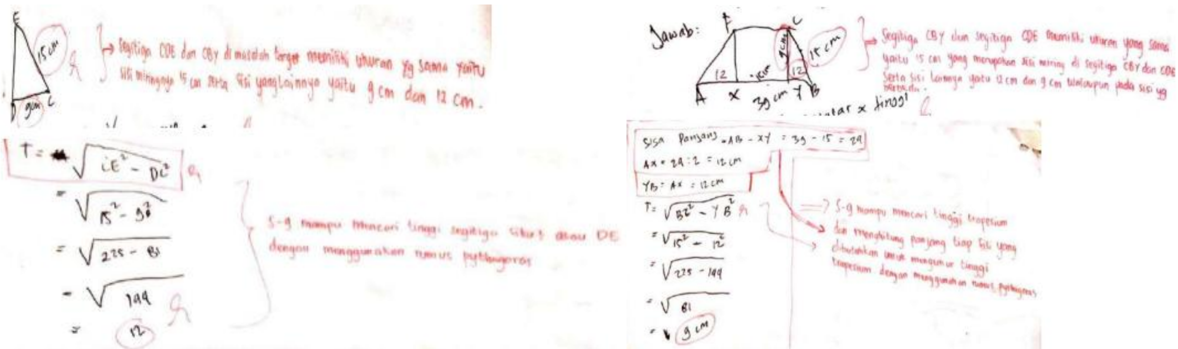


Figure 3. S9 test results on the source problem and target problem at the inferring stage

The results of S9's work in Figure 2 are reinforced by the researcher's interview with S9, as shown below.

P: Do you think there are similarities between the two problems that have been solved?

S9: Yes, ma'am, they both use the Pythagorean theorem and the numbers are the same, namely 15, 12, and 9.

P: Then how do you find the area?

S9: Both shapes are added together.

Based on the test results and interviews, S-9 students were able to recognize similarities between source problems and target problems. S9 students were able to relate the triangular elements in the source problem to the trapezoidal elements in the target problem through the equal-length sloping sides. The students' accuracy in finding the relationship between the numbers 15, 12, and 9 demonstrates their understanding of the Pythagorean triple concept. This also demonstrates the students' ability to generalize from the available information. S9 not only found the information (encoding) but was also able to link the steps to solve both problems. Thus, the inferring stage was demonstrated by S9 through their ability to find conceptual relationships between the information from both problems.

These findings indicate that emotional intelligence supports students' persistence in finding relationships between elements. Research by Setyawan & Simbolon (2018) found that students with good emotional regulation are more persistent in seeking conceptual relationships before moving on to the solution. This is in line with Eva & Kusrini (2016), who stated that students who are able to manage emotional pressure are more consistent in the mathematical inference process. Additionally, Wardhani et al. (2016) emphasize that the success of the inference stage in analogical reasoning depends on the ability to map structural similarities between problems. This aligns with Sternberg & Sternberg (2017) assertion that inference in analogical reasoning requires consistency in connecting old information with new situations. By comparing these results, it can be said that the research findings are consistent with both theory and empirical research. Therefore, the inferring stage in emotionally stable students demonstrates cognitive and affective success that supports analytical thinking processes in solving mathematical problems (Baltazar, 2022).

Mapping stage

Figure 4 shows the results of S9's work in the mapping stage in solving source and target problems. Students appear to be able to connect the solution strategies from the source problem to the target problem by utilizing the similarities in the concepts they have found.

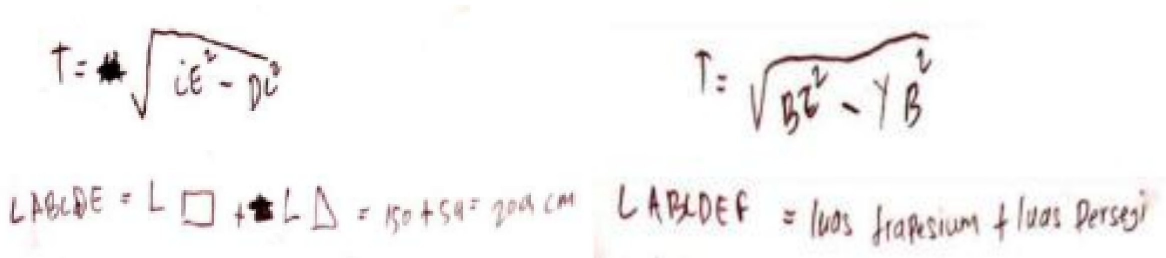


Figure 4. S9 test results on source and target problems in the mapping stage

The results of S9's work in Figure 3 are reinforced by the researcher's interview with the subject, where the student was able to explain how to map the formula and strategy from the source problem to the target problem. The following is a quote from the researcher's interview with S9

P: After you solved the source problem, were there any similar steps that could be used for the target problem?

S9: Yes, ma'am, both use the Pythagorean theorem to find the unknown side.

P: Can you explain further, which side are you referring to?

S9: In the source problem, the height of the triangle is found using the Pythagorean theorem, while in the target problem, the height of the trapezoid must also be found in the same way.

P: Then, what about the area of the shape?

S9: The areas are both added together, ma'am. In the source problem, it's the area of the rectangle plus the area of the triangle, while in the target problem, it's the area of the trapezoid plus the area of the square.

P: So, in your opinion, are the strategies used different or the same?

S9: They're almost the same, ma'am. The shapes are different, but the formulas and steps are similar.

Based on the results of the test and interview, S9 was able to map the problem-solving strategy from the source problem to the target problem effectively. S9 understood that both problems required the application of the Pythagorean theorem to determine the unknown side length. This understanding became the foundation for equating the method of calculating the areas of different figures. Such awareness indicates a well-developed ability in analogical reasoning. The process of mapping these similarities involved deep conceptual reasoning. Thus, the mapping stage was successfully fulfilled by the student.

S9's findings are consistent with studies that emphasize the importance of concept mapping in analogical reasoning. Rosyidi (2024) explained that students who are able to transfer strategies from one problem to another demonstrate a higher level of conceptual understanding. This is further supported by Ardani & Ningtiyas (2017) and Wardhani et al. (2016), who showed that analogy mapping strengthens mathematical problem-solving skills. Similarly, Vendetti et al. (2015) highlighted that mapping constitutes the core of analogical reasoning, as it connects similar structures across different domains. In line with this, English (2004) added that the mapping process reinforces the interconnection between visual and procedural representations in problem solving. This view is also supported by Eva & Kusrini (2016), who found that emotional regulation influences students' fluency in connecting concepts across problems as well as their creativity. Therefore, the mapping stage serves as a crucial bridge between initial understanding and the application of relevant strategies in analogical reasoning.

Applying stage

Figures 5 and 6 illustrate the work of subject S9 in the applying stage when solving the source and target problems. The student successfully applied the appropriate formulas to determine the area of each figure, both in the source problem and in the target problem.

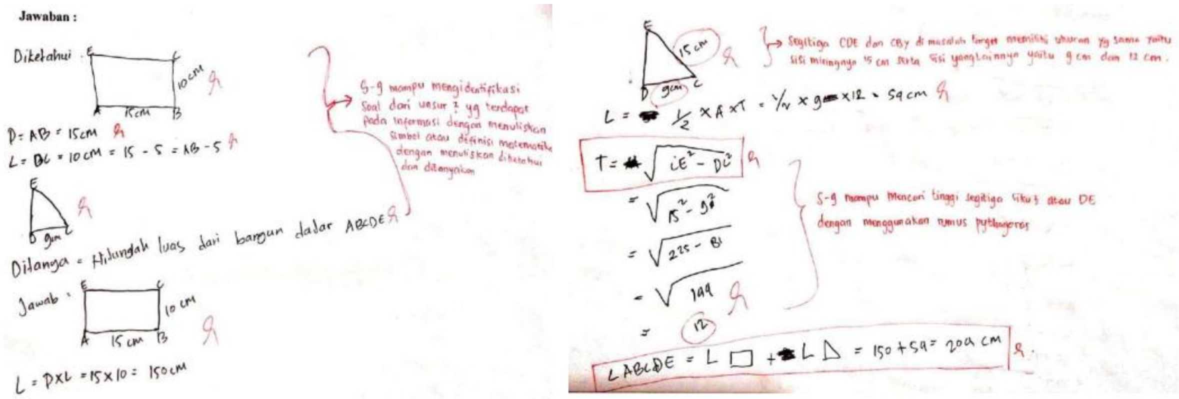


Figure 5. S9's Test Result on the Source Problem in the Applying Stage

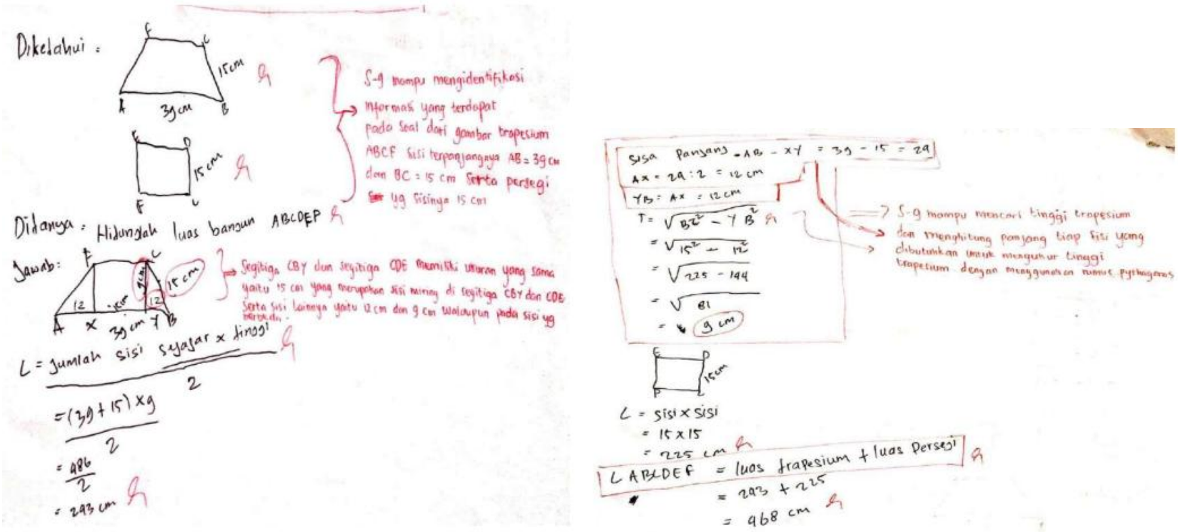


Figure 6. S9's Test Result on the Target Problem in the Applying Stage

The results of S9's work in Figures 5 and 6 were further supported by the interview findings. An excerpt from the interview between the researcher and S9 is presented below.

P: Now, in the source problem, what did you calculate first?
S9: I calculated the area of the rectangle first, Ma'am.
P: What is the formula for the area of a rectangle?
S9: Length times width, Ma'am..
P: Besides the rectangle, what other shape did you calculate?
S9: The area of the right triangle, Ma'am.
P: What is the formula for the area of that triangle?
S9: One-half times base times height, Ma'am.
P: In the target problem, what figure did you calculate first?
S9: The area of the trapezoid, Ma'am.
P: Could it be calculated directly?
S9: Not yet, Ma'am, because the height was not given.
P: Then what did you do?
S9: I drew an auxiliary line, then used the Pythagorean theorem to find the height.
P: After finding the height, what was the next step?
S9: Then I could calculate the area of the trapezoid, and afterwards add the area of the square given in the target problem.

Based on the results of the test and interview, S9 was able to apply calculation strategies systematically. S9 demonstrated the ability to adjust strategies when the given information was incomplete, such as in the case of the trapezoid's height. The student's ability to construct auxiliary lines and apply the Pythagorean Theorem reflects flexibility in thinking. This also indicates that S9 did not easily give up when encountering obstacles during problem solving. Furthermore, the consistency in the solution steps shows that S9 possessed strong procedural skills. Therefore, the applying stage was successfully achieved, as S9 was able to apply mathematical concepts to arrive at the correct solution.

These results indicate that emotional intelligence supports students in overcoming computational obstacles during the applying stage. Research by Purnama (2016) and Faizi (2018) confirmed that students with high emotional persistence are more capable of continuing their calculations despite difficulties. This is consistent with the study by Kapur & Rummel (2012), which found that students' success in problem solving is influenced by their ability to cope with challenges. Similarly, Tuti et al. (2018) demonstrated that students with good emotional regulation are more effective in applying mathematical strategies. These findings also align with English (2004), who emphasized that the application of concepts in analogical problems requires both cognitive and affective persistence.

Furthermore, Mayer & Salovey (2007) and Setyawan & Simbolon (2018) revealed that strong applying skills are associated with students' perseverance in repeating calculation steps until successful. Students with a resilient mindset are more likely to succeed in applying concepts to complex problems (Baltazar, 2022). This is further supported by Eva & Kusrini (2016) and Rosida (2015), who showed that emotional regulation influences students' courage in taking computational steps. Thus, the applying stage represents the culmination of the integration between students' conceptual, procedural, and emotional knowledge.

Overview of Students' Analogical Reasoning with High Emotional Intelligence

Table 1. Stages of Analogical Reasoning in Students with High Emotional Intelligence when Solving Source and Target Problems

Stage	Description of Students' Work
Encoding	Able to identify the known and unknown elements in both the source and target problems.
Inferring	Able to discover relationships among elements, such as numerical similarities and patterns, through the application of the Pythagorean theorem.
Mapping	Able to map problem-solving strategies from the source problem to the target problem using similar concepts.
Applying	Able to accurately apply area formulas, utilize auxiliary lines, and consistently solve the problems.

Table 1 presents a comprehensive depiction of students' analogical reasoning abilities with high emotional intelligence. In the encoding stage, students demonstrated accuracy in recognizing the key elements of the problems. The inferring stage highlighted students' ability to connect given information in order to construct new knowledge and solve problems. The mapping stage showed students' skill in transferring strategies across different problems. In the applying stage, students successfully integrated these strategies through the correct use of formulas, leading to accurate solutions. Overall, these four stages illustrate a strong consistency in analogical reasoning, supported by the students' emotional stability.

These findings strengthen the view that emotional intelligence plays a significant role in supporting mathematical reasoning processes. Research by Setyawan & Simbolon (2018) and Eva & Kusrini (2016) revealed that students with higher emotional regulation are more systematic in solving multi-step problems. This is consistent with Baltazar (2022), who emphasized the link between emotional intelligence and success in problem solving and analytical thinking. Goleman (2005) noted that emotional intelligence helps individuals cope with frustration during critical thinking. Similarly, Kapur & Rummel (2012) highlighted that emotional intelligence enables students to reach solutions despite initial failures. This suggests that a resilient mindset and strong emotional capacity are crucial for successfully applying mathematical strategies across various contexts (English, 2004; Ramdhani et al., 2019). Therefore, this study demonstrates that students' success in each stage of analogical reasoning is not solely determined by cognitive factors, but also by the strength of their emotional intelligence.

CONCLUSION

This study demonstrates that students with high emotional intelligence are able to consistently solve geometry problems through analogical reasoning. In the encoding stage, students were able to clearly identify the known and unknown elements of the problems. In the inferring stage, they successfully established relationships among the elements and employed the Pythagorean Theorem as the basis for problem solving. The mapping stage revealed students' ability to accurately transfer strategies from the source problem to the target problem. Finally, the applying stage confirmed their skills in applying area formulas through systematic and accurate calculation steps. Based on these findings, future research is recommended to involve a larger number of subjects with varying levels of emotional intelligence in order to obtain a more comprehensive understanding.

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