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Students' Mathematical Abstraction in Constructing Quadrilateral Concepts: A Learning Style Perspective

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ABSTRACT

Mathematical abstraction is an important aspect in mathematics learning, especially in helping students form and understand geometric concepts such as quadrilaterals. However, in practice, students' mathematical abstraction process does not always occur uniformly. This is due to differences in individual characteristics, one of which is learning style. Therefore, this study aims to describe the profile of students' mathematical abstraction in forming the concept of quadrilaterals in terms of learning style. This study uses a qualitative approach with a descriptive type. The research subjects consisted of three seventh-grade junior high school students with visual, auditory, and kinesthetic learning styles. Data were collected through a learning style questionnaire, mathematical abstraction tasks on quadrilaterals, and interviews. Data analysis used data condensation, data display, and conclusion drawing and verification. The results of the study showed that students' mathematical abstraction processes differed in each learning style. Visual students were able to go through all aspects of mathematical abstraction (recognizing, building-with, constructing, and consolidation) gradually by utilizing visual representations. Auditory students also achieved all aspects by relying on verbal understanding, although the constructing and consolidation aspects were not systematically arranged. Meanwhile, kinesthetic students rely more on concrete experiences and physical activity in recognizing and consolidating. Therefore, it can be concluded that learning styles determine how students carry out the mathematical abstraction process in forming the concept of quadrilaterals, so this needs to be taken into consideration when designing mathematics learning.

Keywords: mathematical abstraction; quadrilaterals; learning styles

INTRODUCTION

Mathematics is characterized by its abstract concepts (Khasanah et al., 2021). This often leads to students experiencing difficulties in understanding mathematical concepts. In the process of learning mathematics, students require abstraction to understand abstract concepts. Krisnadi, (2022) stated that understanding various ideas, concepts, and concepts in mathematics that have abstract objects of study also requires a specific activity or process called abstraction. Mathematical abstraction is an individual's mental process in forming new concepts by utilizing the student's prior experience and knowledge (Nurhasanah et al., 2017). Mathematical abstraction often occurs when someone ignores tangible objects and only focuses on objects that can be understood; this activity is a form of sensory characteristics (Nurhasanah et al., 2017). Therefore, mathematical abstraction is very important in understanding abstract mathematical concepts, because some mathematical concepts are formed through the process of abstraction (Memnun et al., 2017). Mathematical abstraction is used by students when they encounter abstract mathematical concepts, especially when recognizing, combining, and constructing concepts in problem solving (Hodiyanto et al.,

2024). Through abstraction, students will discover the concepts to be learned, making learning more meaningful for them because abstraction encourages students to connect prior knowledge with the knowledge being learned (Agra et al., 2019). This allows students to not only memorize formulas but also understand concepts well and be able to form new concepts.

One of the mathematical topics that demands mathematical abstraction is geometry, particularly quadrilaterals. The concept of quadrilaterals encompasses the definition and properties of quadrilaterals. Understanding this concept relies not only on memorizing formulas but also on students' ability to form new concepts from prior understanding (Hodiyanto et al., 2024). Therefore, students' mathematical abstraction process can be observed when working on quadrilateral assignments. These activities demonstrate how students process their existing knowledge to construct concepts. Therefore, it is important to consider the factors that influence this process.

One of the factors that influences the development of students' mathematical abstraction is learning style. According to Aini et al., (2025) learning style has a positive and significant influence on students' mathematical abstraction. Learning style is an individual's way of absorbing, processing, and understanding information (Khoeron et al., 2014). Every student has a different learning style. Learning styles according to Zagoto et al., (2019) are (1) visual learning style, namely the ability to learn by seeing, (2) auditory learning style, namely having better ability in hearing, and (3) kinesthetic learning style, namely learning by involving movement.

Field phenomena indicate that the process of mathematical abstraction in quadrilateral material has not been seen in students' conceptual understanding. As a result, students tend to memorize formulas without understanding the underlying concepts. This condition hinders the formation of new concepts that should be built from students' abstract understanding. The difficulty of abstraction in quadrilateral material occurs because students' understanding is still limited (Lushfatun Nisa, 2018).. Based on the results of an interview with one of the teachers at SMP Negeri 1 Palu, it was discovered that students actually have initial knowledge about the concept of quadrilaterals. However, when viewed overall, students still struggle to understand the concept in depth. This indicates that to be able to understand the concept of quadrilaterals requires a process, namely mathematical abstraction. In addition, each student has a different learning style that influences how they absorb information and form mathematical concepts (Khoeron et al., 2014).

Several previous studies have shown that mathematical abstraction plays an important role in concept formation. Nurhasanah et al., (2017) found that the abstraction process helps students construct concepts through prior experiences. Furthermore, Hodiyanto et al., (2024) research shows that abstraction stages such as recognizing, building-with, constructing, and consolidation can be used to analyze students' thought processes in understanding geometric concepts. Other studies have also shown that differences in student characteristics, such as learning styles, influence how the abstraction process occurs (Aini et al., 2025). However, previous studies generally only focus on general mathematical abstraction abilities without in-depth descriptions of how the abstraction process occurs in students with different learning styles. Research that specifically examines the mathematical abstraction process based on the RBC+C stages in terms of learning styles in quadrilateral

material at the junior high school level is still limited. Thus, this study demonstrates the need for a more in-depth study of how students with different learning styles carry out the mathematical abstraction process in forming quadrilateral concepts. The novelty of this research lies in the profile of students' mathematical abstraction in forming the concept of a quadrilateral using the RBC+C stages, reviewed based on their learning styles. This research not only describes the final results of students' understanding but also reveals students' thinking processes at each stage of mathematical abstraction according to the characteristics of their learning styles.

Based on the description, the problem formulation in this study is how the profile of students' mathematical abstraction in forming the concept of a quadrilateral based on the RBC+C stages is viewed from the learning style. The purpose of this study is to describe the profile of students' mathematical abstraction in forming the concept of a quadrilateral viewed from the learning style. The results of this study are expected to provide benefits for teachers in understanding students' thinking processes based on learning styles so that they can be used as a basis in designing more effective learning and in accordance with student characteristics.

RESEARCH METHODS

This research is a descriptive qualitative study aimed at describing students' mathematical abstraction in forming the concept of quadrilaterals from the perspective of their learning styles. The study was conducted at SMP Negeri 1 Palu in the 2025/2026 academic year. The data source for this study was seventh-grade students selected as research subjects. Subject selection was based on the results of a Learning Style Questionnaire (VAK), which consisted of 30 statements with three answer choices: A, B, and C. Choice A indicates a visual learning style, B an auditory learning style, and C a kinesthetic learning style (Nizaruddin et al., 2020). From the questionnaire results, one student was selected, representing each learning style type with high mathematical ability.

The research instruments consisted of the researcher as the primary instrument, the learning style questionnaire, a mathematical abstraction task on quadrilaterals (as shown in Figure 1), and an interview guide as a supporting instrument. The learning style questionnaire was used to identify students' learning style tendencies. The mathematical abstraction task used consisted of four questions, a descriptive text on quadrilaterals. The instrument underwent expert validation before being used in the study and was deemed suitable for use with several improvements as suggested by the validator. It was then administered to the research subjects, followed by interviews to obtain more in-depth data regarding the students' thinking processes in solving the problems.

Data validity was verified through a credibility test using member checks and a dependability test to ensure the consistency of the data obtained. Data analysis used the qualitative data analysis model from (Miles et al., 2014) and was conducted iteratively, including data condensation, data display, conclusion drawing and verification. The analysis process was carried out by grouping the data from the questionnaire, assignments, and interviews based on the mathematical abstraction aspects of the RBC+C model (Hodiyanto et al., 2024). These aspects are outlined in Table 1.

Table 1. Aspects of Mathematical Abstraction

Aspect	Explanation
(Recognizing) (R)	Recalling the previous concept about the characteristics and definitions of various types of quadrilaterals.
(Building-with) (B)	Combining the previous concepts on quadrilaterals.
(Constructing) (C)	Rebuilding the previous concept of quadrilateral into a new concept of quadrilateral.
(Concolidation)(+C)	Strengthen understanding of concepts that have been formed and make it easier to carry out subsequent activities.

RESULTS AND DISCUSSION

The learning style questionnaire was given to grade VII students of SMP Negeri 1 Palu with the results in Table 2.

Table 2. Classification of Learning Styles

Subject	Learning Style	Total	Mathematical Ability
AJ	Visual	3	High
JN			
NF			
BA	Auditory	1	
QA	Kinesthetic	2	
RP			

Based on Table 2, there are three students with a tendency towards visual learning styles, one student with an auditory learning style, and two students with a kinesthetic learning style, all of whom have high mathematical abilities. Next, one student from each learning style type was selected as the research subject, namely the student with the highest mathematical ability score. The selected subjects were AJ for the visual learning style, BA for the auditory learning style, and QA for the kinesthetic learning style. All three subjects have high mathematical abilities as determined based on the results of the learning test. Next, the three students were given an assignment on the material of quadrilaterals, as shown in Figure 1.

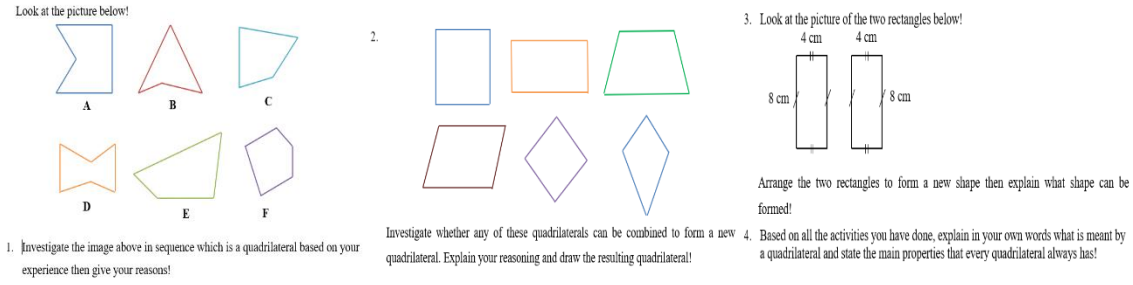

Figure 1. Quadrilateral Material Assignment

Recognizing (R) Aspect

In this aspect, students are asked to pay attention to question number 1 in figure 1 of the quadrilateral assignment. This is to help them recall concepts previously learned in the

quadrilateral material. Analysis of the answer sheets, observations, and interviews revealed three students with different learning styles, as follows.

Visual Students

In the recognizing (R) aspect, visual students are able to recognize the concept of a quadrilateral by observing the basic characteristics of the shape. Students identify quadrilaterals by the number of sides, with four sides being the main characteristic. Furthermore, students also consider the overall shape of the shape as a support in the recognition process. This is supported by the following interview results in Table 3.

Table 3. Visual Subject Dialogue during Recognizing

Code	Interview
PN	What was the first thing you noticed in picture 1 of the quadrilateral material assignment in question number 1?
AJ	I noticed the sides of the shape.
PN	Which one is the side?
AJ	*Point out the side in the picture*.
PN	How many sides does it have?
AJ	*Count the sides of each shape*. There are four.
PN	Besides the building's appearance, what else do you notice?
AJ	I also saw the shape of the building.

Based on the quotations in Table 3, it can be seen that students directly linked the observed visual information to their prior knowledge about the characteristics of quadrilaterals. This process indicates that students use visual representations as a basis for recognizing concepts. Thus, in the recognizing aspect, visual learners tend to rely on observations of the sides and shapes of the shapes to connect the information obtained with existing concepts. This research finding aligns with Natonis et al., (2022) who stated that students with a dominant visual learning style excel in visual representation skills because they tend to solve problems using images. Therefore, visual learners are able to recognize all quadrilaterals well.

Auditory students

In the recognition (R) aspect, auditory students recognize the concept of a quadrilateral by focusing on the number of sides of the shape. Students identify a quadrilateral as a shape with four sides without considering other characteristics such as the shape or overall appearance of the shape.

This is supported by the interview results in Table 4 below.

Table 4. Auditory Subject Dialogue during Recognizing

Code	Interview
PN	What was the first thing you noticed in picture 1 of the quadrilateral material assignment in question number 1?
BA	I noticed the number of sides.
PN	Besides the building's appearance, what else do you notice?
BA	Nothing else.

Based on the quotations in Table 4, students briefly observed information with prior knowledge that quadrilaterals have four sides. However, recognition was still limited to the number of sides without considering other visual aspects such as shape. The analysis results also showed that auditory students tended to be less thorough and rushed, resulting in errors and no rechecking. The findings of this study are in line with Asmaliyah et al., (2023) who stated that auditory students tended to not determine the right strategy and were less thorough in working on questions because they were rushed. Thus, in the aspect of recognition, auditory students identified quadrilaterals based on the number of sides as the main characteristic without utilizing the visual aspect more broadly.

Kinesthetic Students

In the recognizing (R) aspect, kinesthetic students can partially identify shapes by looking at the sides of a shape. However, they have difficulty initially recognizing whether a shape is a quadrilateral or not. Students cannot immediately identify the shape's characteristics but instead need time to think and recall previously learned concepts.
This is supported by the interview results in Table 5 below.

Table 5. Dialogue of Kinesthetic Subjects during Recognizing

Code	Interview
PN	What was the first thing you noticed in picture 1 of the quadrilateral material assignment in question number 1??
QA	At first, I couldn't figure out what I should pay attention to.
PN	So, what do you do to figure out the quadrilateral from question 1?
QA	I tried to recall what I knew, and then I remembered that a quadrilateral has four sides.

Based on the quotations in Table 5, students did not directly link visual information to their concepts, but rather through a process of recall until they concluded that a quadrilateral has four sides. This process was accompanied by physical activities, such as playing with a pen and moving fingers, which reflects a kinesthetic learning style. However, there were still errors in identifying the shape, so the recognition process was not consistent. Thus, in the recognizing aspect, kinesthetic students recognized concepts through recall combined with physical activities until they were able to identify the main characteristics of quadrilaterals. The findings of this study are in line with Damayanti et al., (2025) who stated that kinesthetic students tend to learn while moving, have difficulty remaining still for long periods, and express understanding through physical activity.

Building-with (B) Aspect

In this aspect, students are asked to pay attention to question number 2 in Figure 1 of the quadrilateral assignment. This is to help them combine previously recognized concepts (quadrilaterals) to form new concepts. Analysis of the answer sheets, observations, and interviews revealed three students with different learning styles, as follows.

Visual Students

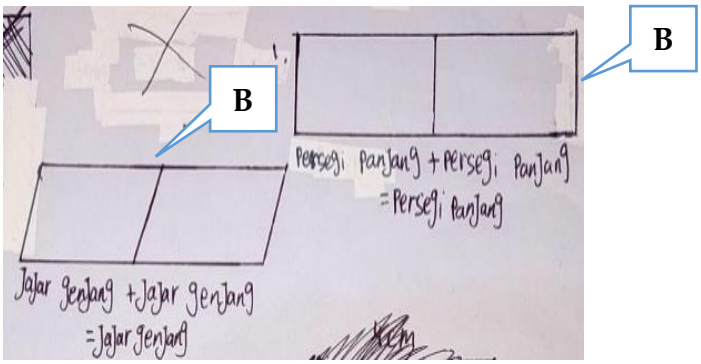

Figure 2. Visual Student Answers at the Building-with Stage (B)

Figure 2 shows that visual students are able to systematically combine two quadrilaterals to form a new shape. Students are able to integrate similar shapes, such as two rectangles or two parallelograms, into a larger shape. This indicates that in the building-with aspect, visual learners utilize visual representations systematically to combine quadrilateral concepts in new situations. The findings of this study are in line with the findings of Natonis et al., (2022) who stated that students with a dominant visual learning style use visual representations in solving problems. Thus, visual learners in the building-with aspect are able to utilize visual representations to systematically integrate quadrilateral concepts to form new shapes.

Auditory Students

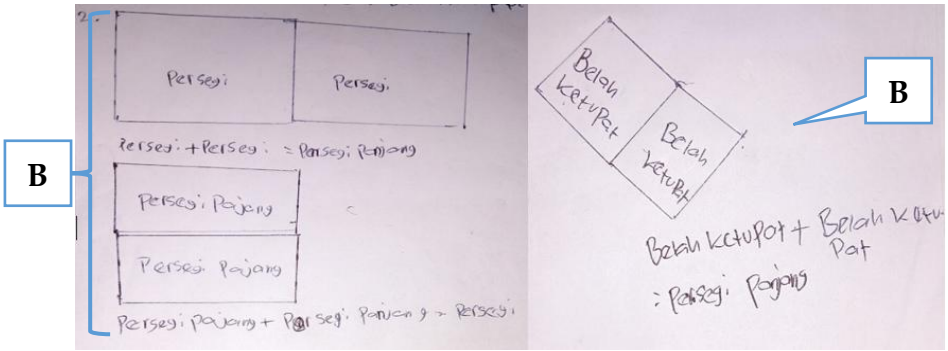

Figure 3. Auditory Student Answers at the Building-with Stage (B)

Figure 3 shows that auditory students are able to combine several plane figures with more diverse variations. In this process, students not only combine similar figures, but also combine different figures while still considering the characteristics of quadrilaterals, namely having four sides. This ability shows that in the building-with aspect, auditory students are able to develop and integrate concepts through verbal understanding by linking information thought or expressed verbally into the strategy of combining figures. The findings of this study are in line with (DePorter & Hernacki, 2001) who stated that the auditory learning style supports the development of knowledge through listening and speaking activities. Thus, auditory students are able to carry out the mathematical abstraction process in the building-with aspect by integrating various quadrilateral concepts through their verbal understanding.

Kinesthetic Students

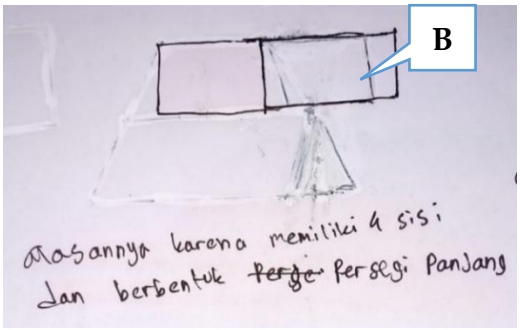

Figure 4. Kinesthetic Student Answers at the Building-With Stage (B)

Figure 4 shows that kinesthetic students still have limitations in combining previously acquired concepts. Students are only able to combine shapes that are still limited to one variation. This indicates that in the building-with aspect, kinesthetic students begin to use the concepts they have, but the integration is still limited and less varied. The findings of this study are in line with Apipah et al., (2018) who stated that students with a kinesthetic learning style tend to experience difficulties when having to integrate several mathematical concepts, especially in materials that require abstract visualization and high reasoning. Thus, kinesthetic students in the building-with aspect are not yet fully able to integrate various mathematical concepts flexibly to form new concepts.

Constructing (C) Aspect

In this aspect, students are asked to pay attention to question 3 in Figure 1 of the quadrilateral assignment. This is to help students not only rely on previously acquired quadrilateral concepts but also construct new concepts through a process of integration. The results of the analysis of the answer sheets, observations, and interviews obtained from three students with different learning styles are as follows.

Visual Students

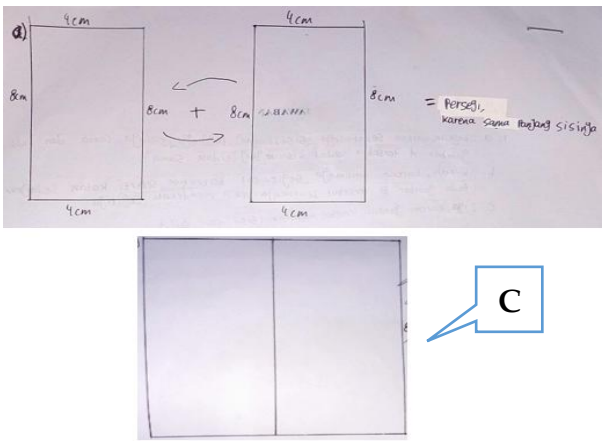

Figure 5. Visual Student Answers at the Constructing Stage (C)

Figure 5 shows that visual students are able to construct new concepts through the process of combining shapes. Students can be seen combining two rectangles into a square.

Students are not only able to recognize the characteristics of shapes but are also able to form new concepts related to quadrilaterals. This indicates that in the constructing aspect, visual learners perform mathematical abstraction by integrating previous concepts to produce new understanding through visual representations. The findings of this study are in line with Anwar et al., (2022) who stated that students with a visual learning style tend to use images, patterns, and visualizations of shapes predominantly in solving problems. Thus, visual learners have good abilities in mathematical abstraction in the constructing aspect.

Auditory Students

In the constructing aspect (C), auditory students are able to construct new concepts through the process of combining quadrilaterals. Based on the given problem, students can conclude that two rectangles can be arranged into a new shape in the form of a square.

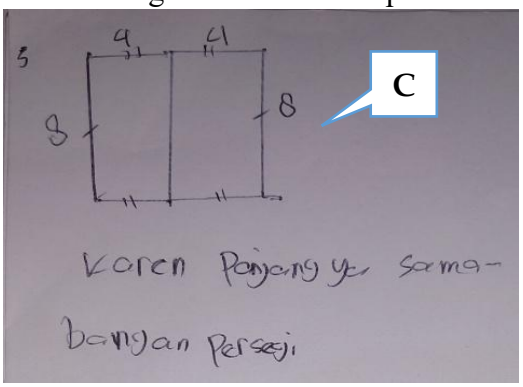

Figure 6. Auditory Student Answers at the Constructing Stage (C)

Figure 6 shows that auditory students are able to construct new concepts through the process of combining quadrilaterals. This indicates a concept construction process from integrating existing concepts. However, students' explanations do not describe the steps and reasons in detail, so the flow of concept formation is not yet clear. Thus, in the constructing aspect, auditory students have carried out mathematical abstraction, although their explanations are still limited. The findings of this study are in line with Jaenudin et al., (2017) who stated that auditory students tend not to explain in detail when interpreting a case based on mathematical concepts. Therefore, at this stage, auditory students have not yet expressed the concept construction process systematically and in depth. Although they have demonstrated the ability to integrate existing concepts to form new concepts.

Kinesthetic Students

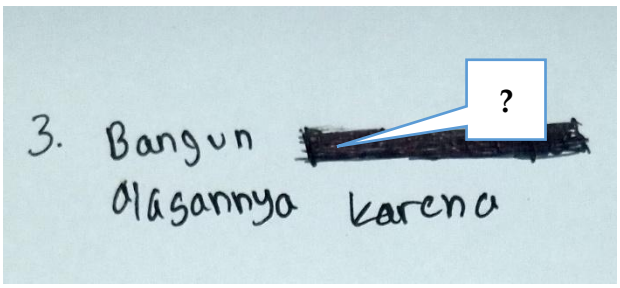

Figure 7. Answers Of Kinesthetic Students at the Constructing Stage (C)

Figure 7 shows that kinesthetic students were unable to construct new concepts related to quadrilaterals. This is evident in their incomplete answers. Students had difficulty imagining the results of combining shapes abstractly, making them unable to identify new shapes that might be formed from the two given shapes.
This is supported by the interview results in Table 6 below.

Table 6. Dialogue between Kinesthetic Subjects during Constructing

Code	Interview
PN	Do you think two rectangles with a length twice their width can be arranged into a new shape? What shape would be formed?
QA	*Thinking*. I can't think of any shape that could be arranged.

Based on the quotation in Table 6, students are not yet able to imagine or predict the new shape of the combination of two rectangles. In the constructing aspect, kinesthetic students have not fully carried out mathematical abstraction, especially those that require visualization or abstract thinking, and still rely on direct experience. The findings of this study are in line with (Supit et al., 2023) who stated that kinesthetic learning styles more easily understand concepts through physical activity or direct practice. Thus, kinesthetic students have not demonstrated optimal mathematical abstraction in the constructing aspect.

Consolidation (+C) Aspect

In this aspect, students are asked to pay attention to question number 4 in Figure 1 of the quadrilateral assignment. This is to help students strengthen their understanding of the concept of quadrilaterals by stating the definition in their own words and stating the main properties of quadrilaterals. The results of the analysis of the answer sheets, observations, and interviews obtained from three students with different learning styles are as follows.

Visual Students

Table 7. Visual Subject Dialogue during consolidation

Code	Interview
PN	After completing the test, can you now distinguish between the different types of quadrilaterals?
AJ	Yes. I can now distinguish between squares, rectangles, and parallelograms. What conclusions did you draw from the test?
PN	All quadrilaterals have one thing in common they have four sides.
AJ	

Based on the quotation in Table 7, it appears that students were able to identify the main similarity of quadrilaterals, namely, they have four sides. Students were able to restate the knowledge they had acquired and use it to differentiate between different types of quadrilaterals. This demonstrates that the concepts they had learned were not only understood but also integrated into their knowledge. Therefore, in the consolidation aspect, visual students demonstrated that the knowledge they had built had been well internalized, allowing it to be reused in understanding and explaining the concept of quadrilaterals in other activities. This research finding aligns with (Breive, 2022) who stated that the

consolidation process helps students use the abstractions they have constructed to facilitate the completion of subsequent activities.

Auditory Students

Table 8. Auditory Subject Dialogue during consolidation

Code	Interview
PN	After completing the test, can you now distinguish between the different types of quadrilaterals?
BA	Yes. I can now distinguish between squares, rectangles, and rhombuses.
PN	What conclusions did you draw from the test?
BA	I can distinguish between quadrilaterals and know that a quadrilateral must have four sides.

Based on the quotation in Table 8, it can be seen that students are able to state the similarities between quadrilaterals, namely having four sides, and distinguish between several types of shapes. However, the delivery of conclusions is still general and has not been structured in a more coherent definition. This is in line with Wijayanti et al., (2019) who stated that students with an auditory learning style are able to explain mathematical ideas and draw conclusions, but the explanations given tend to still rely on verbal information received. Thus, in the consolidation aspect, auditory students have re-expressed the concepts learned, but the knowledge built has not been fully organized systematically and therefore not fully depicted in their explanations.

Kinesthetic Students

Table 9. Kinesthetic Subject Dialogue during consolidation

Code	Interview
PN	After completing the test, can you now distinguish between the different types of quadrilaterals?
QA	Yes. I can now distinguish between squares and rectangles.
PN	What conclusions did you draw from the test?
QA	A quadrilateral is a shape with four sides.

Based on the quotation in Table 9, it is clear that kinesthetic students are able to understand the basic concept of quadrilaterals through the process of identifying and simplifying concepts. This is evident in the students' ability to distinguish several types of quadrilaterals, such as squares and rectangles, and to conclude that a quadrilateral is a shape with four sides. This ability indicates that students have achieved an initial conceptual understanding of the material being studied, although their understanding is still at a simple and in-depth level. This is because kinesthetic students more easily understand concepts through direct experience and concrete activities. This finding is in line with Amperawaati & Yunitasari, (2024) who stated that students with a kinesthetic learning style are more enthusiastic and better understand learning through experimental activities and direct experience.

The results of the study indicate that students' mathematical abstraction process in forming the concept of a quadrilateral differs in each learning style based on the RBC+C stages, namely recognizing, building-with, constructing, and consolidation. Visual students are able to go through all stages of mathematical abstraction well because they utilize visual representations in recognizing, combining, and forming new concepts. Visual students tend to use observations of the sides and shapes of shapes to understand the concept of a quadrilateral and are able to construct new shapes through visualization. This finding is in line with research (Natonis et al., 2022; Anwar et al., 2022) which states that visual students find it easier to understand mathematical concepts through pictures and visualization of shapes.

In contrast to visual students, auditory students performed mathematical abstraction through verbal understanding. Auditory students were able to recognize and combine quadrilateral concepts well; however, their explanations were not yet systematic and lacked detail. This occurred because auditory students relied more on verbal information than on visual observation. These findings support the research (Asmaliyah et al., 2023; Jaenudin et al., 2017) which state that auditory students tend to be less meticulous and are not yet able to explain their thinking processes in detail.

Meanwhile, kinesthetic students demonstrated mathematical abstraction processes that were more dependent on concrete experiences and physical activities. Kinesthetic students experienced difficulties at the constructing stage because they were not yet able to imagine the combination of shapes abstractly. Nevertheless, they were still able to understand the basic concepts of quadrilaterals through direct activities and by recalling previously learned concepts. These findings are in line with the studies of (Damayanti et al., 2025; Supit et al., 2023) which state that kinesthetic students more easily understand concepts through direct experiences and physical activities. Overall, this study demonstrates that learning styles influence the ways students carry out mathematical abstraction processes in forming quadrilateral concepts, and therefore should be taken into consideration in the design of mathematics instruction. This study not only reveals the final outcomes of students' understanding but also explains the students' thinking processes in constructing mathematical concepts according to the characteristics of their respective learning styles.

CONCLUSION

Students' mathematical abstraction process in forming the concept of a quadrilateral differs for each learning style based on the RBC+C stages, namely recognizing, building-with, constructing, and consolidation. Students with a visual learning style are able to go through all stages of mathematical abstraction well by utilizing visual representations, such as observing the shape and sides of the shape, so they are able to recognize, combine, and construct new concepts systematically. Auditory students are also able to achieve all stages of mathematical abstraction by relying on verbal understanding, although at the constructing and consolidation stages the explanations given are not yet structured in detail and systematically. Meanwhile, kinesthetic students show a mathematical abstraction process that relies more on concrete experiences and physical activity. Kinesthetic students are able to recognize and understand the basic concept of a quadrilateral, but experience difficulties

at the constructing stage because they are not yet able to imagine combining shapes abstractly. Thus, learning styles determine how students carry out the mathematical abstraction process in forming the concept of a quadrilateral. Therefore, teachers need to consider the characteristics of students' learning styles in designing mathematics lessons so that the concept formation process can take place more optimally.

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