

Profile of Junior High School Students' Mathematical Abstraction in Forming the Concept of Triangles

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Abstract. *This study aims to describe the profile of junior high school students' mathematical abstraction in forming the concept of triangles in terms of high, medium, and low levels of mathematical ability, based on the aspects of RBC+C, namely recognizing, building-with, constructing, and consolidation. This study uses a descriptive qualitative approach with three seventh-grade students as subjects, one student each with high, medium, and low mathematical ability, selected based on the results of a mathematical ability test. Data were collected through triangle abstraction assignments and interviews, then analyzed using the Miles and Huberman model which includes data condensation, data presentation, and drawing and verifying conclusions. The results showed that students with high mathematical ability were able to pass all aspects of RBC+C optimally, students with medium ability were able to reach all aspects but not optimally, while students with low ability experienced limitations in almost all aspects of mathematical abstraction, especially in the aspects of building-with, constructing, and consolidation. Thus, the level of students' mathematical ability significantly influences the quality of the mathematical abstraction process in forming the concept of triangles.*

Keywords: *Mathematical Abstraction, Concept, Triangle, Mathematical Ability, RBC+C*

INTRODUCTION

Mathematics is a subject closely related to various concepts. Students need to understand basic mathematical concepts, such as numbers, arithmetic operations, geometry, algebra, and statistics, which are abstract. Khatin-Zadeh (2023) explains that the abstract nature of mathematics is characterized by symbols or concepts that do not directly refer to objects that can be perceived concretely. This abstract nature makes understanding mathematical concepts an important foundation for students in carrying out the thought process called abstraction.

The abstraction process occurs when a person recognizes the same characteristics of an object based on previous experiences they have had (Fitriani et al., 2018). Meanwhile, Nurhasanah et al., (2017) stated that when a person ignores real objects and only focuses on objects that can be understood mentally, this reflects the sensory characteristics in the mathematical abstraction process. So abstraction allows individuals

to form new concepts by eliminating unimportant things based on previous understanding and knowledge. In mathematics learning, the mathematical abstraction process is used by students when facing conceptual material, such as numbers, algebra, geometry, and functions that require students to think not only on concrete objects, but also on more general representations. In line with the opinion of Kholid & Aisyah (2025) who stated that the mathematical abstraction process plays an important role for students in generalizing concepts, developing logical thinking, and solving more complex mathematical problems. On the other hand, if students are unable to carry out the mathematical abstraction process well, it will cause students to experience obstacles in understanding concepts, making representations, and solving mathematical problems (Munawwaroh et al., 2025). Through the process of abstraction, students can construct and understand the concepts they learn, making learning more meaningful. This occurs because abstraction helps students connect their prior knowledge with the new concepts or information they are learning (Agra et al., 2019).

The results of research conducted by Ismiyati et al., (2023) also show that many students still experience difficulties in defining the concept of triangles, classifying types of triangles, and drawing various triangle shapes. These difficulties indicate that weak mastery of basic triangle concepts not only hinders the learning process but also impacts students' ability to perform mathematical abstraction. One factor that influences mathematical abstraction is students' mathematical ability. Research conducted by Nadilia et al., (2023) found that there are differences in the mathematical abstraction process between students with high and medium mathematical abilities. Where students with high abilities show a more complete abstraction process than students with medium abilities. Students with medium abilities tend to only reach problem solving without any strengthening of arguments. Thus, students' mathematical abilities are an important factor in developing optimal mathematical abstraction.

Various previous studies have shown that students' mathematical abstraction abilities are still a concern in mathematics learning. Research conducted by Nur & Ramlan (2021) stated that students' mathematical abstraction in triangle material is still relatively low, because only high-ability students fulfill all aspects of abstraction.

Meanwhile, more students with medium and low abilities have not been able to achieve the abstraction aspect optimally.

Various previous studies have shown that students' mathematical abstraction abilities remain a concern in mathematics learning. Nur & Ramlan (2021) revealed that students' mathematical abstraction abilities in triangle material are still relatively low, where only high-ability students are able to fulfill all aspects of mathematical abstraction, while students with medium and low abilities have not been able to achieve it optimally. This finding is relevant to this study because it shows that students' mathematical ability levels significantly influence their mathematical abstraction aspects in triangle material at the junior high school level, but differ in the use of aspects to view students' mathematical abstraction abilities. In line with this, Hodiyanto et al., (2024) revealed that mathematical abstraction can be analyzed through gradual epistemic actions using the RBC+C aspect, although the study still focused on quadrilateral material. Unlike the two previous studies, this study specifically examines the mathematical abstraction profile of seventh-grade junior high school students in triangle material based on high, medium, and low levels of mathematical ability using the RBC+C aspect.

This is reinforced by an interview with a math teacher at a junior high school in Palu City who stated that most students are familiar with the basic concepts of triangles. However, mastery of these basic concepts is not always accompanied by students' ability to abstract to form new concepts. Furthermore, differences in students' mathematical abilities, whether high, medium, or low, also influence their abstraction abilities. Based on these conditions, this research is important to be conducted to describe the mathematical abstraction of junior high school students in Palu City in forming the concept of triangles that pay attention to high, medium, and low levels of mathematical ability.

RESEARCH METHOD

This study uses a descriptive qualitative approach that aims to describe or depict students' mathematical abstraction in forming the concept of triangles. The research subjects were selected 3 seventh grade students of one of the State Junior High Schools in Palu in the even semester of 2025/2026, each with high, medium, and low

The instrument used to obtain data in abstracting uses a triangle abstraction problem task sheet as in Figure 1. To check the validity of the data, a credibility test (member check) is used. The data analysis of this research uses the Miles and Huberman model which includes data condensation, data display, as well as conclusion drawing and verification (Miles et al., 2014).



Table 1. Classification of Students' Mathematical Ability Levels

Based on Table 1, the data obtained shows that there are 4 students with high abilities, 18 students with medium abilities, and 7 students with low abilities. In this study, the

researcher took three subjects, namely 1 student each with high, medium, and low abilities to conduct a mathematical abstraction test.

Data collection related to mathematical abstraction was carried out by giving assignments on the triangle material. The test instrument used consisted of four questions designed to represent each aspect of mathematical abstraction, namely: (1) recognizing (*recognizing*) (R), (2) build-with (*building-with*) (B), (3) construct (*constructing*) (C), and (4) consolidation (*consolidation*) (+C). The aspects of mathematical abstraction that are used as guidelines in this research are presented in Table 2 below.

Table 2. Explanation of RBC+C Abstraction Aspects

Aspect	Explanation
Getting to know (<i>recognizing</i>) (R)	Recognize and recall previous concepts about the characteristics and definitions for the concept to be built.
Build-with (<i>building-with</i>) (B)	Combine previous concepts to form new concepts on triangles.
Constructing (<i>constructing</i>) (C)	Reorganize the previous concept into a new structure on the triangle concept.
Consolidation (<i>Concolidation</i>) (+C)	Strengthen understanding of concepts that have been formed and make it easier to carry out subsequent activities.

Hodiyanto et al., (2024)

RESULT AND DISCUSSION

Aspects of Recognition (*Recognizing*) (R)

MA subjects

HereThe results of the MA subject interviews on the Recognizing aspect are in Table 3 below.

Table 3. MA Subject Interview Recognizing Aspect

	Interview
	PN In question number 1, what do you see in the triangle image?
	MA That's a picture of a triangle with different shapes, sis.
	PN Where can you see the difference?
R	MA From the shape, brother, the size of the angle, the shape of a triangle, line one and line two on the sides of the triangle
	PN Do you know where the names and properties of each triangle come from?
R	MA I learned this in elementary school, so I still remember. The triangular shape is also quite different.

VT Subject

HereThe results of the VT subject interviews on the Recognizing aspect are in Table 4 below.

Table 4. VT Subject Interview Recognizing Aspect

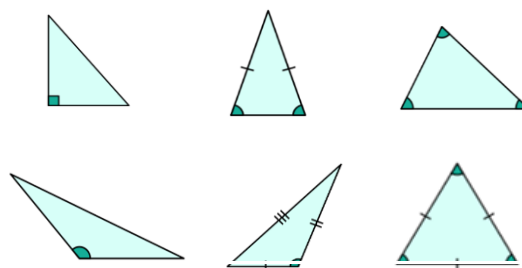
Interview	
PN	In question number 1, what do you see in the triangle image?
VT	Different shapes of triangles, sis
PN	Where can you see the difference?
VT	I saw the shape, right? Then I saw the angles and the length of the sides.
PN	Do you know where the names and properties of each triangle come from?
VT	I actually learned it back in elementary school, Sis. But there are some things I can't remember.

YP Subject

HereThe results of the YP subject interview on the Recognizing aspect are in Table 5 below.

Table 5. YP Subject Interview Recognizing Aspect

Interview	
PN	In question number 1, what do you see in the triangle image?
YP	Different shapes of triangles, sis
PN	Where can you see the difference?
YP	Judging from the shape of the picture, each triangle is different.
PN	Do you know where the names and properties of each triangle come from?
YP	I've studied it before, brother, but there are some that I've forgotten. So I just looked at the triangular shape to know its properties.

**Figure 2. Triangle Shape in the Observed Question**

From the data results of the three subjects above, it shows that subject MA is able to recognize the types of triangles and shows that students have reactivated conceptual memory acquired since elementary school as a foundation for recognizing the concept of triangles presented. This finding is in line with Hodiyanto et al., (2024) which states that students' initial understanding is an important basis in the mathematical abstraction process in the aspect *recognizing*, because it helps students identify relevant information and relate it to previously learned concepts. Therefore, students with high mathematical abilities have reached the aspect of recognizing (*recognizing*) in the process of optimal mathematical abstraction.

VT subjects can recognize several types of triangles and shows that the subject has reactivated the conceptual understanding acquired since elementary school. However, in recognizing obtuse and acute triangles is still limited, indicating that some of the previously acquired conceptual knowledge is starting to be forgotten. This finding shows that students have been able to recognize the basic characteristics of triangles through visual attributes and geometric properties, but have not been able to identify all types of triangles consistently. This condition indicates that the process *recognizing* has occurred, but the conceptual knowledge possessed is not yet fully stable. From a geometric perspective, this ability corresponds to Van Hiele's level of analysis (Level 1), namely students begin to recognize the properties of shapes, but do not yet fully understand the relationships between these properties, so they still have difficulty in classifying the types of triangles correctly (Casanova et al., 2021). This process indicates that students are still able to reactivate previously learned conceptual knowledge about triangles, although not completely intact. This finding is in line with Aziza and Imami (2025) who stated that students with moderate abilities are able to remember and distinguish the characteristics of objects based on direct experience, but their abstract thinking and idealization abilities are still limited.. Therefore, students with moderate mathematical abilities have reached the aspect of recognizing (*recognizing*) in the process of mathematical abstraction but not yet optimal.

Subject YP was not yet able to recognize the types of triangles and still made mistakes in grouping triangles because he only relied on visual observation without an adequate understanding of the concept of triangles. When observing the triangular shapes

in Figure 2, we are not yet able to connect the visual information observed with previous knowledge about the concept of triangles by observing each shape. different triangles in Figure 2. However, they are not yet fully able to explain the properties of acute and obtuse triangles completely, and still experience errors in grouping triangles. This process shows that some of the triangle concepts learned since Elementary School have begun to be forgotten, so that students rely more on visual observation of the different shapes of triangles. Students generally prioritize the overall appearance of a shape over its defining attributes when identifying triangles (Simon et al., 2026). Thus, in the aspect of recognize (*Recognizing*) (*R*) Low-ability students tend to only be able to identify shapes visually without a deep understanding of the concept. This finding is in line with Ayna et al., (2024) which states that students with low abilities tend to only be able to identify shapes without understanding the concept in depth. Therefore, students with moderate mathematical abilities have reached the aspect of recognizing (*recognizing*) in the process of mathematical abstraction but less than optimal.

Building Aspects – with (*Building – With*) (*B*)

MA subjects

The following are the interview results and answers to the MA written test on the Building aspect – in Table 6 below.

Table 6. MA Subject Interview Building Aspect - With

Interview	
PN	In your opinion, is an equilateral triangle an acute triangle?
MA	Yes, sis. Because all angles in an equilateral triangle are equal, each measuring 60° , and all angles are less than 90° , an equilateral triangle is an acute triangle.
PN	Is an obtuse triangle an arbitrary triangle?
MA	Yes, if the obtuse triangle has sides of different lengths.
PN	Are there triangles that can be grouped based on the length of their sides and the size of their angles at the same time?
MA	There is, for example, an isosceles triangle is a right triangle because all the angles of an isosceles triangle are less than 90° .
PN	Try to describe it!

MA

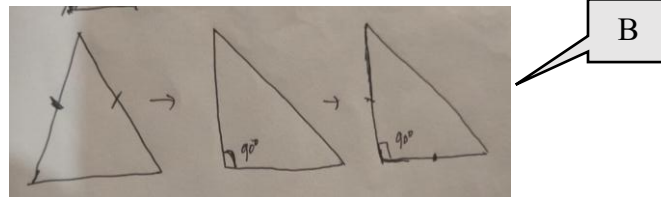


Figure 3. MA Answer Combines the Triangle Concept

VT Subject

The following are the interview results and answers to the VT written test on the Building aspect – in Table 7 below.

Table 7. VT Subject Interview Building Aspect - With
Interview

PN	In your opinion, is an equilateral triangle an acute triangle?
VT	Yes, because if I look at it, an equilateral triangle also has the same angles as an acute triangle.
PN	Is an obtuse triangle an arbitrary triangle?
VT	It is possible, if the sides are not the same length.
PN	Are there triangles that can be grouped based on the length of their sides and the size of their angles at the same time?
VT	Yes, sis, obtuse triangles are included in any triangle (<i>students repeat previous answers</i>).
PN	Try to describe it!
VT	

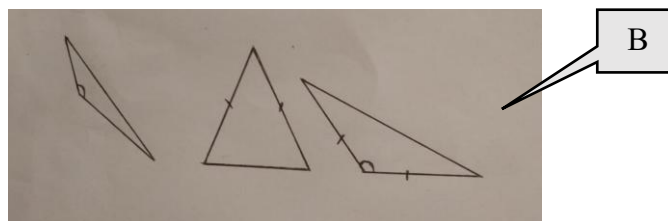


Figure 4. VT Answer Combining Types of Triangles

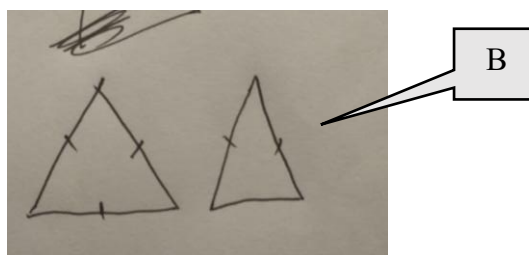
YP Subject

The following are the interview results and answers to the VT written test on the Building aspect – in Table 8 below.

Table 8. YP Subject Interview Building Aspect - With
Interview

PN	In your opinion, is an equilateral triangle an acute triangle?
YP	I think so, because if you look at an equilateral triangle, the ends of the corners are sharp.
PN	So if it's an obtuse triangle, is it an arbitrary triangle?

- YP Yes, you can, sis, if the obtuse triangle has sides that are not the same length.
- PN Are there triangles that can be grouped based on the length of their sides and the size of their angles at the same time?
- YP Yes, an equilateral triangle with an isosceles triangle because their shape is almost the same.
- PN Try to describe it!
- YP



Gambar 5. YP Answer Combining Types of Triangles

From the data results of the three subjects above, it shows that MA subjects can combine isosceles triangles with right triangles to form a new concept, namely the concept of an isosceles right triangle. This process demonstrates that students use their understanding of the concepts of side length and angle size as a basis for independently constructing new concepts. In RBC+C theory, these activities include epistemic actions *building-with*, namely the use of existing knowledge to generate solutions to mathematical problems. At this stage, completely new mathematical structures have not yet been formed, but students have made meaningful use of existing structures (Hershkowitz et al., 2001; 2020). Thus, in the aspect of building-with (*Building-With*), students rely on a strong understanding of previous concepts to combine them to form new concepts appropriately. The findings of this study are in line with (Hodianto et al., 2024) which states that the formation of new concepts requires a strong prior understanding as a solid foundation for thinking.

VT subjects can combine their understanding of triangle shapes based on side lengths and angles, namely obtuse triangles and arbitrary triangles, to form a new concept in the form of an arbitrary obtuse triangle. However, students are still mistaken in visualizing triangle shapes. They draw an obtuse triangle with an isosceles triangle, which becomes an obtuse isosceles triangle. In addition, the ability to combine triangle concepts is still limited because students are only able to repeat previously given answers without being able to

develop or find new examples independently. Alghadari & Noor, (2021) stated that the validity of abstraction results lies in the relationship between properties that reflect the interaction between figural and conceptual aspects. From a geometric thinking perspective regarding the development of geometric thinking, it shows that students at Level 1 Van Hiele are often able to name the properties of shapes, but are not yet able to connect several of these properties into a complete classification (Nusaibah et al., 2021). Therefore, students with medium abilities have demonstrated abilities in the aspect of building with (*Building-With*) in the process of mathematical abstraction but not yet optimal.

Subject YP was unable to combine an isosceles triangle with an equilateral triangle to form a new concept: an equilateral triangle is an isosceles triangle. This finding indicates that students' understanding of the triangle concept is still limited, relying solely on the visual appearance of the triangle without a deeper understanding of its conceptual characteristics. This is in line with Hutagalung et al., (2020) found that low-ability students are not yet able to understand the concept of triangles formally mathematically, but only recognize triangles based on visual features and characteristics they commonly encounter, without being accompanied by in-depth conceptual understanding. Therefore, low-ability students in the mathematical abstraction process in the aspect of building-with (*Building-With*) is not optimal.

Constructing Aspects (*Constructing*) (C)

MA subjects

The following are the results of the MA's answers to the Building aspect – in Figure 6 below.

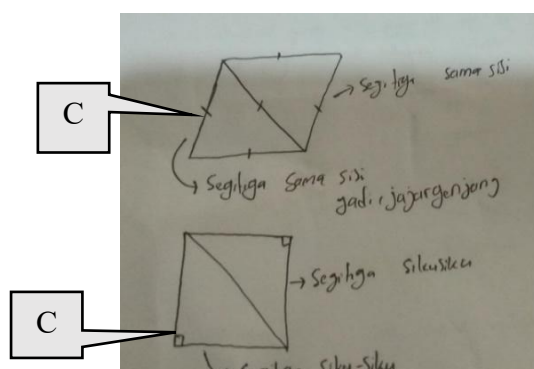


Figure 6. MA Answers in Constructing Triangles

VT Subject

The following are the results of VT's answers to the Building aspect – in Figure 7 below.

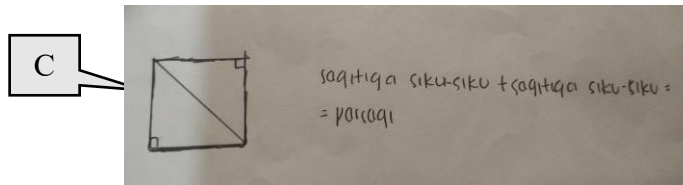


Figure 7. VT Answers in Constructing Triangles

YP Subject

The following are the results of YP's answers to the Building aspect – in Figure 8 below.

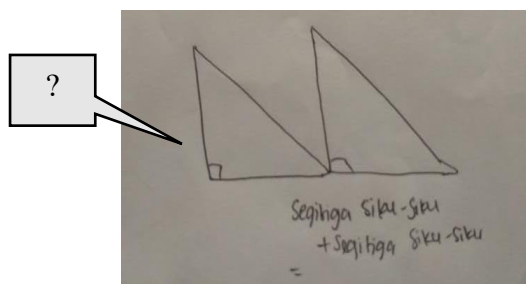


Figure 8. YP Answers in Constructing Triangles

From the data results of the three subjects above, MA shows that High ability students can construct two isosceles triangles to form a parallelogram. Students construct A parallelogram is formed by combining two congruent equilateral triangles. The subject rotates one of the triangles 180° and then overlaps it with one side of the other triangle. This creates a diagonal of the new shape. This combination results in the opposite sides of the shape being equal in length and parallel (Grasegger & Legerský, 2020). Likewise, he was able to construct two right-angled triangles to form the concept of a square. This finding aligns with Syarifudin et al. (2024) who stated that students with high mathematical abilities are able to construct new structures from previously learned concepts. Therefore, students with high mathematical abilities are optimal in the mathematical abstraction process, particularly in the constructing aspect.

VT Subject only discover one new structure from all the possibilities that exist. Students with medium ability can construct two isosceles right triangles to form the concept of a square. Students construct a square by combining two congruent right

triangles, that is, two triangles with exactly the same side and angle measurements, where each triangle has one right angle of 90° . The formation is done by overlapping the hypotenuses of the two right triangles, so that the overlapping sides become the diagonals of the new shape formed. As a result of this combination, the four sides of the shape become the same length and the four angles become right angles (90°), in accordance with the properties of a square. This indicates a process of vertically reorganizing previously constructed mathematical concepts, resulting in the formation of a new mathematical structure (Budiarto et al., 2017). Thus, in this aspect of constructing, students with moderate ability are able to form new structures from the concept of triangles that have been learned, although their achievement is not yet comprehensive. This finding is in line with Syarifudin et al., (2024) who stated that students with moderate ability show the ability to construct new concept structures, but their achievement of mathematical abstraction is not yet comprehensive because several indicators have not been able to be met. Therefore, it can be concluded that students with moderate mathematical ability have achieved the aspect of constructing in the mathematical abstraction process but it is not yet optimal.

YP Subject not yet able to unite two triangles into a complete flat shape. The subject's construction of two right-angled triangles indicates that although a new concept was formed, the subject only drew two right-angled triangles placed side by side and meeting at a vertex, without squeezing the two triangles at their hypotenuses. As a result, the two triangles did not form a complete quadrilateral. The student also did not write a conclusion about what shape was formed from the combination. Thus, the subject was not yet able to construct the concepts of triangles that had been learned into a new structure of understanding. This finding is in line with Fitriani & Rohaeti, (2020) who stated that students with a low level of abstraction tend to experience misconceptions and are not yet able to construct geometric concepts into new, more complex structures. Therefore, students with moderate mathematical abilities have achieved the construction aspect in the mathematical abstraction process but less than optimally.

Consolidation Aspect (*Consolidation*) (+C)

MA subjects

The following are the results of the MA's answers to the Building aspect – in Figure 3 below.

Table 9. MA Subject Interviews on Consolidation Aspect

Interview	
PN	After answering the questions given, what new understanding have you gained about triangles?
MA	I learned that triangles can be two types at once, sis. If two triangles of the same shape and size are combined at their corresponding sides, a new plane shape can be formed.
PN	What are some examples?
MA	For example, two equilateral triangles form a parallelogram and two triangles form a square.

VT Subject

The following are the results of the MA's answers to the Building aspect – in Figure 3 below.

Table 10. Subject Interview V T Consolidation Aspect

Interview	
PN	After answering the questions given, what new understanding have you gained about triangles?
VT	The new understanding I gained is that triangles can be grouped based on the length of their sides and the size of their angles, sis.
PN	Are there any new insights you gained?
VT	Yes, sis, if two identical right triangles are joined at their hypotenuses, they can become a square.

YP Subject

The following are the results of the MA's answers to the Building aspect – in Figure 3 below.

Table 11. VT Subject Interview Consolidation Aspect

Interview	
PN	After answering the questions given, what new understanding have you gained about triangles?
YP	(students are confused and cannot answer)
PN	So, is there any conclusion that you can get?
YP	In conclusion, there are many types of triangles.

From the data results of the three subjects above, the MA subject succeeded in compiling a complete conclusion and new understanding as a foundation for further learning. The subject expressed his new understanding that two types of triangles are based on the length of the sides and the size of the angles simultaneously. In addition,

students were able to relate these properties to the concept of forming new plane figures, namely that two congruent triangles combined on the corresponding sides can form another plane figure, by giving the appropriate example of two equilateral triangles forming a parallelogram, and two right triangles forming a square. This finding is in line with Breive (2022) which states that consolidation is the final stage of mathematical abstraction, where the understanding that has been built is confirmed as a foundation for further learning. Therefore, high-ability students have reached the consolidation aspect (*consolidating*) in the process of optimal mathematical abstraction.

The VT subject was able to express his new understanding that triangles can be grouped based on the length of their sides and the size of their angles. In addition, students also linked these properties to the concept of forming new plane figures, namely that two congruent right triangles when joined at their hypotenuses will form a square. This shows that students are able to connect knowledge about the properties of triangles with the concept of forming plane figures appropriately. Pielsticker, (2022) showed that students who have understood the characteristics of triangles tend to be better able to apply this understanding in more complex contexts, for example in the process of forming various plane figures. Therefore, students with medium abilities have achieved the consolidation aspect (*consolidating*) in the process of mathematical abstraction but not yet optimal.

YP subjects were unable to develop complete and structured conclusions and new understandings. Students were only able to state that triangles have many types, without being able to further explain the properties of triangles (side lengths and angles) or relate them to the concept of forming new plane figures. This finding aligns with Breive (2022) who stated that inability at the constructing stage results in failure to reach the consolidating stage. Casanova's (2021) research also showed that students at the visualization level often fail to recognize triangles when their orientation or type changes because they rely on prototype examples stored in memory. Therefore, students with low abilities in the consolidation aspect of the mathematical abstraction process are not optimal.

CONCLUSION

The mathematical abstraction process of students in forming the concept of triangles shows significant differences at each level of mathematical ability based on the RBC+C stages, namely recognizing, building-with, constructing, and consolidating. In the aspect of recognizing, students with high mathematical ability have achieved this aspect optimally, students with medium mathematical ability have achieved this aspect but not optimally, while students with low mathematical ability have not achieved this aspect. In the aspect of building-with (*building-with*), students with high mathematical abilities have achieved this aspect optimally, students with medium mathematical abilities have achieved this aspect but not optimally, while students with low mathematical abilities have not achieved this aspect. In the constructing aspect (*constructing*), students with high mathematical abilities have achieved this aspect optimally, students with medium mathematical abilities have achieved this aspect but not optimally, while students with low mathematical abilities have not achieved this aspect. In the consolidation aspect (*consolidating*), students with high mathematical abilities have achieved this aspect optimally, students with medium mathematical abilities have achieved this aspect but not optimally, while students with low mathematical abilities have not achieved this aspect.

Thus, it can be concluded that the higher the students' mathematical abilities, the more optimal the achievement of the RBC+C aspect in the mathematical abstraction process on the triangle concept.

ACKNOWLEDGMENTS

Teachers need to consider the differences in students' mathematical abilities when designing more differentiated geometry learning, so that the process of mathematical abstraction and the formation of the triangle concept can take place more optimally for all students.

REFERENCES

Agra, G., Formiga, N. S., Oliveira, P. S. de, Costa, M. M. L., Fernandes, M. das G. M., & Nóbrega, M. M. L. da. (2019). Analysis of the concept of meaningful learning

in light of Ausubel's theory. *Revista Brasileira de Enfermagem*, 72(1), 248.
<https://doi.org/10.1590/0034-7167-2017-0691>

Arikunto, S. (2013). *Dasar-dasar Evaluasi Pendidikan* (edisi 2) (2 end ed). PT Bumi Aksara. Jakarta: Bumi Aksara

Ayna, Q., & Sari, D. I. (2024). Deskripsi Berpikir Visual Siswa dalam Memahami Materi Geometri Menggunakan Geogebra Ditinjau dari Perbedaan Kemampuan Matematika. *Jurnal Pendidikan Matematika dan Sains* 12(1), 72–84.
<https://doi.org/10.21831/jpms.v12i1.73252>

Aziza, A. K., & Imami, A. I. (2024). Studi kasus kemampuan abstraksi matematis siswa kelas XI pada materi fungsi. *Jurnal Didactical Mathematics*, 7(1), 12–19.
<https://doi.org/10.31949/dm.v7i1.11917>

Breive, S. (2022). Abstraction and embodiment : exploring the process of grasping a general. *Educational Studies in Mathematics*, 1, 313–329.
<https://doi.org/10.1007/s10649-021-10137-x>

Budiarto, M. T., Khabibah, S., & Setianingsih, R. (2017). *Construction of High School Students ' Abstraction Levels in Understanding the Concept of Quadrilaterals*. 10(2), 148–155. <https://doi.org/10.5539/ies.v10n2p148>

Fitriani, N., & Rohaeti, E. E. (2020). Miskonsepsi siswa pada materi geometri di tingkat sekolah menengah pertama. *Teorema: Teori dan Riset Matematika*, 5(1), 9–16.
<http://dx.doi.org/10.25157/teorema.v5i1.3267>

Fitriani, N., Suryadi, D., & Darhim, D. (2018). Analysis of mathematical abstraction on concept of a three dimensional figure with curved surfaces of junior high school students. *Journal of Physics: Conference Series*, 1132(1).
<https://doi.org/10.1088/1742-6596/1132/1/012037>

Grasegger, G., & Legerský, J. (2020). Bracing frameworks consisting of parallelograms. *arXiv*. 1–20. <https://doi.org/10.48550/arXiv.2008.11521>

Hodiyanto, Budiarto, M. T., Ekawati, R., Susanti, G., Kim, J., & Bonyah, E. (2024). How abstraction of a pre-service teacher in constructing relationships among quadrilaterals. *Journal on Mathematics Education*, 15(2), 339–362.
<https://doi.org/10.22342/jme.v15i2.pp339-362>

Hutagalung, E. E., Mulyana, E., & Pangaribuan, T. R. (2020). Mathematical abstraction : students ' concept of triangles. *Journal of Physics: Conference Series*, 1521(3), 032106. <https://doi.org/10.1088/1742-6596/1521/3/032106>

- Ismiyati, N. (2023). Deskripsi Proses Abstraksi Matematika Siswa Berdasarkan Gaya Kognitif. *Jurnal Penelitian Matematika dan Pendidikan Matematika*, 6, 267–277. <https://doi.org/10.30605/proximal.v6i1.2301>
- Khatin-Zadeh, O., Eskandari, Z., & Farsani, D. (2023). The Roles of Mathematical Metaphors and Gestures in the Understanding of Abstract Mathematical Concepts The Roles of Mathematical Metaphors and Gestures in the Understanding of Abstract Mathematical Concepts. *Journal of Humanistic Mathematics*, 13(1), 36-35. <https://doi.org/10.5642/jhummath.BZXW2115>.
- Kholid, M. N., & Aisyah, N. N. (2025). Classification of Abstract Thinking in Solving Mathematical Problems. *Educational Process: International Journal* 16. <https://doi.org.10.22521/edupij.2025.16.194>
- Lisa, A., Benjamin, S., & Maike, R. (2026). Exploring strategies for the identification of triangles by students with learning difficulties : an eye - tracking study. *Mathematics Education Research Journal*, 38(2), 353–379. <https://doi.org/10.1007/s13394-025-00531-6>
- Miles, M. B., Huberman, A. M., & Saldana, J. (2014). *Qualitative Data Analysis: A Methods Sourcebook* (3 ed.). Sage Publications Ltd.
- Miles, M. B., Huberman, M., & Saldana, J. (2014). *Qualitative-Data-Analysis*. SAGE.
- Munawwaroh, A. G., Pramudya, I., & Nurhasanah, F. (2025). Epistemological Obstacles in the Process of Learning Mathematical Abstraction : A systematic literature review. *KnE Social Sciences*. 272–294. <https://doi.org/10.18502/kss.v10i11.18749>
- Nadilia, B., & Wijayanti, P. (2023). Abstraksi reflektif siswa SMP dalam menyelesaikan masalah matematika ditinjau dari kemampuan matematika. *MATHE dunesa: Jurnal Ilmiah Pendidikan Matematika*, 12(3), 684–697. <https://doi.org/10.26740/mathedunesa.v12n3.p684-697>
- Noor, N., & Alghadari, F. (2021). Case of Actualizing Geometry Knowledge in Abstraction Thinking Level for Constructing a Figure. *Journal of Educational Studies in Mathematics*. 8(1), 16–26. <https://doi.org/10.17278/ijesim.797749>
- Nurhasanah, F., Kusumah, Y. S., & Sabandar, J. (2017). Concept of triangle: Examples of mathematical abstraction in two different contexts. *International Journal on Emerging Mathematics Education*, 1(1), 53–70. <https://doi.org/10.12928/ijeme.v1i1.5782>

Pielsticker, F. (2022). Description of the activated mathematical knowledge of the triangle concept in three empirical contexts. *International Electronic Journal of Mathematics Education*, 17(4), em0697. <https://doi.org/10.29333/iejme/12170>

Sitihanifah, N., & Ramlah. (2021). Analisis Kemampuan Abstraksi Matematis Siswa. *MAJU: Jurnal Ilmiah Pendidikan Matematika*, 8(2), 168–174. <https://etheses.uinsgd.ac.id/55717/>

Syarifudin, M. T., Ratnaningsih, N., & Ni'mah, K. (2021). Analisis Kemampuan Abstraksi Matematis Dalam Pembelajaran Matematika Di MAN 1 Tasikmalaya. *MUST: Journal of Mathematics Education, Science and Technology*, 6(2), 231–240. <https://doi.org/10.30651/must.v6i2.7461>

Miles, M. B., Huberman, A. M., & Saldana, J. (2014). *Qualitative Data Analysis: A Methods Sourcebook* (3rd ed.). Sage Publications Ltd.