# Visual Representation Profile of Junior High School in Solving The Geometric Word Problem

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## ABSTRACT

Visual representation is essential to provide an aid for the student to understand geometry word problems. A proper representation can help them to recognize a context of the problem and ease to plan the appropriate strategy to solve this. This qualitative study therefore aims to describe the profile of visual representation in solving geometric word problems. The subjects of this study were 30 students of class 9A MTs Negeri 3 Mojokerto in the 2024/2025 academic year. The results of the study reveals that 4 students used accurate schematic representation, 15 students used inaccurate schematic representation, and 11 students used pictorial representation. Students whom used accurate schematic representation described objects carefully and paid attention on the size, location, and distance between objects. Meanwhile, students whom used inaccurate schematic representation described the objects and the distance between the two objects, but there were some imperfections such as depicting lines representing sunlight (including depicting non-straight, non-single lines with various directions, not touching objects, cutting objects, through the back of the building) and not comparable between one line segment and another. In the meantime, students with pictorial representation only made drawing objects in the form of buildings and trees, and only added 1 information about the distance between the two objects.

**Keywords**: Visual representation, accurate schematic representation, inaccurate schematic representation, pictorial representation, geometry word problem solving.

## INTRODUCTION

A problem is a state that cannot be directly found a way out. Every human being must have problems in their life. Therefore, the ability to solve problems is necessary for the student to learn for, in order to survive, no

matter what kinds of the problems they may encounter. Furthermore, the mindset how to solving problems can be learned by students through learning activity at schools. Therefore, this aims to ensure that students have the ability to survive and struggle in finding solutions to each problem they face. One of the efforts to accustom students at school to learning by linking concepts to problems around them and trying to find solutions. By getting used to solving problems like this, students' mindsets in dealing with problems will be formed well.

In mathematics, particularly geometry, problem solving also plays an important role to build students' mindsets, considering that geometry has many applications in the environment around students. Geometry is a mathematics branch that focused on shape, size, space concepts, and the relationships between objects. Therefore, all of these things require the ability to represent the right visuals to understand them properly. Moreover, understanding the concept of geometry requires students' ability to manipulate images in the right way so that they can help them solve the math problems they do.

In mathematics, especially geometry, problem solving has an important role, especially in building the students' mindsets that geometry has been applicable in the environment around students. Geometry is a branch of mathematics that discusses about shape, size, space concepts, and relationships between objects. Thus, all of these require the ability to represent the exact visuals to understand them properly. Therefore, understanding the concept of geometry requires students' ability to manipulate images in precisely, helping them to solve the math problems they have (Goldin, 1998).

Student's visual representation ability is significant in the process of improving understanding of spatial relationships and measurements. In addition, mastery of visual representation in mathematics learning may provide students ability in describing problem situations that require three-dimensional spatial thinking, which is often a challenge in learning geometry for many students (Jitendra & Woodward, 2019).

Representation is one of the five standards of the educational process delivered by NCTM (Council of Teachers of Mathematics, n.d.). This standard maintains the importance of representation ability in the process of learning mathematics. Representation in general can be interpreted as a method used by the students to describe one form to another (Goldin, 1998)

In mathematics education, geometry exam is presented in the form of words. Geometry words are an exam that provide real-world situations that require students to translate verbal information into mathematical representations. These words exam usually require accurate spatial interpretation, such as drawing geometric objects or shapes, determining sizes, angles, and etc. Since the more complex and context-based nature of story problems, visual representation is very important to facilitate students in understanding and solving problems (Hegarty & Kozhevnikov,

1999). The right image will clarify the relationship between geometric objects in the problem and help them identify important information in the problem so that they can plan the right steps to solve it (Van Garderen & Montague, 2003). In many cases, without a clear visual representation, students will have difficulty understanding the structure of the story problem and cause errors in problem solving (Žakelj & Klančar, 2022). This was also conveyed by Duval (2006) and Pape (2001) that visual representation can help students to transform verbal information into a more structured form, thus facilitating the process of thinking and problem solving.

The importance of visual representation in geometric words problem has been conveyed by Aini (2021). Furthermore, this ability is an essential ability to understand the concept of geometry, even at the college level (Yudianto et al., 2018). This is also supported by the opinion of Rahmania (2024). She explained that through the presentation of data in visual form, students learn how to organize and interpret information, which is part of the mathematical thinking process. Visual representation is an effort, decided by students to describe or visualize the mathematical word problems faced in the form of images, diagrams, or symbols that can make it easier for them to solve problems.

In general, visual representation is divided into 3 types. They are accurate schematic representation, inaccurate schematic representation, and pictorial representation (Boonen et al., 2014). Accurate schematic representation is a kind of representation that describes geometric objects accurately and thoroughly, based on the authenticity that referred in the geometric word problem (Boonen et al., 2014; Zahner & Corter, 2010). Therefore, it is necessary to have accuracy and precise calculations in describing accurate schematic representation. To build this skill through a process that begins with reading the geometry word problem repeatedly, identifying the problem by making a scheme, and creating a schema (Anwar et al., 2019). Furthermore, inaccurate schematic representation is a representation that involves objects and relation between them, with mistakenness during presentation. In addition, pictorial representation is a representation that involves pictures or geometric objects without including the relation between the objects inside. In the other hand, several errors in the formation of representation often occur when students interpret information from verbal form to visual or symbolic form. This error is closely related to the lack of student understanding in making the right representative decision (Afriyani et al., 2019; Anwar, 2020). Therefore, decision making to determine the correct representation is significant in this process.

Considering the role of visual representation in solving geometry problems, this research is significant to be conducted. In the mathematics education curriculum at schools, geometry teaching often focuses on teaching concepts and problem solving, but it pays slight attention to the

importance of visual representation that can help students to understand problems. Hence, this study aims to determine the profile of visual representation of junior high school students in solving geometry problems. Through the results of this study, teachers can have an idea about the profile of junior high school students' representation in solving problems, so that they can pay more attention to the process of making visual representations during mathematic teaching process, especially in geometry word problem solving.

## METHOD

This is qualitative descriptive research. Furthermore, the result is a description of the visual representation used by students in answering geometric words problems. The subjects in this study were 30 students of class 9-A MTs Negeri 3 Mojokerto in the 2024/2025 academic year. By utilizing the average and standard deviation of the mathematics score data, the 30 students were classified into 6 high-ability students, 18 medium-ability students, and 8 low-ability students. The instrument in this study was in the form of geometry problem-solving test questions in the form of story questions about similarity material. Through this test, it can be seen how students use visual representations during solving geometric words problems. In addition, the data in this study were in the form of student work results on word problem-solving tests. Furthermore, all data were then analyzed based on qualitative data analysis steps in the form of data reduction, data presentation, and drawing conclusions.

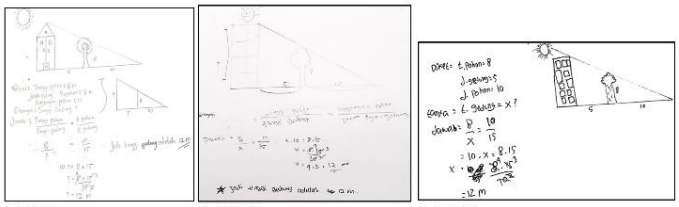
## FINDINGS AND DISCUSSION

The following are the results and discussions obtained from this study.

### 1. Student used accurate schematic representations

Based on 30 research subjects, there were 4 students who used accurate schematic representation, with 3 high-ability subjects and 1 low-ability subject.

Figure 1:
The result of student's work using Accurate Schematic Representation to solve the geometry word problem



(a) ST1 (b) ST3 (c) SS1

Figure 1 (a) ST1 shows that a high-ability student using accurate schematic representation in re-presenting the word problem to solve. While on the right side, the student re-depicted it in the form of two triangles with overlapping in the corner. This student solved the word problem correctly and provided an appropriate conclusion. Figure 1 (b) ST3 shows a high-ability student using accurate schematic representation in presenting information on the word problem through visual representation in the form of images. Thus, it can be seen that the student carefully described all the objects described in the word

problems, about the location of the building, trees and their shadows. Furthermore, they solved the word problems correctly using the concept of similarity and provided an appropriate conclusion. Figure 1 (c) SS1 shows students in moderate group uses accurate schematic representation. The students describe each object correctly and add information to the image. Furthermore, they also determine the problem model and solves it to obtain the right results. However, these students do not provide solution of problem for the conclusion. In general, the thought process of students that use accurate schematic representation can be described as follows.

Figure 2:
Student Chain of Thought that Using Accurate Schematic Representation


Based on the flowchart above, it can be concluded that all students that use accurate schematic representation describe objects carefully and pay attention to the size, location, and distance between objects. Furthermore, one student with high ability that uses accurate schematic representation re-describes it with geometric shapes. In addition, all high-ability students with accurate schematic representation draw conclusions and obtain problem solutions. Meanwhile, students with moderate ability with accurate schematic representation obtained solutions merely from mathematical models.

## 2. Student useed inaccurate schematic representations

Based on 30 research subjects, there were 15 students that used inaccurate schematic representation. There were 4 high-ability students, 8 moderate ability students, and 3 low-ability subjects.

Figure 3:
The result of student's work using Inccurate Schematic Representation to solve the geometry word problem

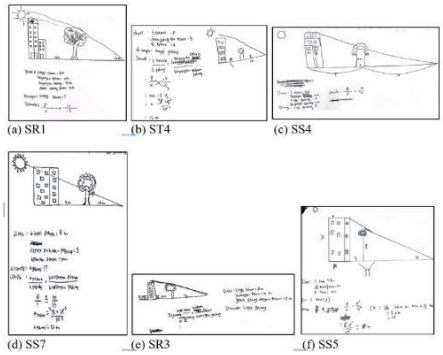
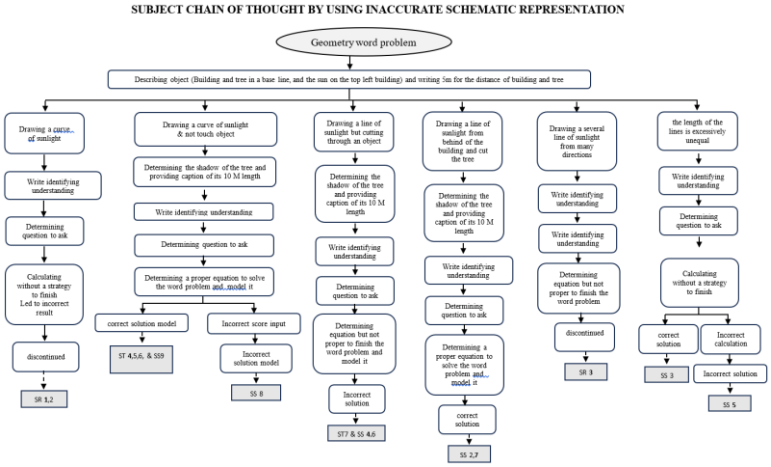


Figure 3 (a) SR1 shows the work results of students with low-ability that use inaccurate schematic representations in solving geometry word problems. The students did not use a straight line to represent sunlight hitting the tip of an object so that a shadow is formed. Furthermore, based on the result, it can be said that the students did not use an appropriate solution strategy. It can be seen from what is written in the form of multiplication between $\frac{8}{x}$ and $\frac{10}{15}$ which is not a concept of similarity in triangles. Figure 3 (b) ST4 is the work of students with a high-ability. They used inaccurate schematic representation. The student represents sunlight with a line that is not straight and does not touch the objects (buildings and trees). Based on the result, it can be said that the students used an appropriate solution strategy and obtained appropriate results. Figure 3 (d)SS7 adalah hasil kerja siswa berkemampuan sedang dengan representasi schemetic tak akurat. Siswa menggambarkan sinar matahari melalui bagian belakang Gedung dan memotong objek (pohon). Jika dilihat dari penyelesaian yang dituliskan, maka dapat dikatakan siswa tersebut menggunakan strategi pemecahan yang sesuai dan memperoleh hasil yang sesuai untuk masalah tersebut. Figure 3 (c) SS4 is the work of students with moderate ability. They used an inaccurate schematic representation. The student described sunlight cutting through an object (tree). Based on the result, it can be said that the student did not use the appropriate solution strategy as conducted by SR1 in Figure 3 (a), namely using multiplication between 8/x and 10/15 which is not a concept of similarity in triangles. Figure 3 (d) SS7 is the work of students with moderate ability. They used inaccurate schematic representation. The student depicted sunlight through the back of the building and cuts through the object (tree). Based on the result, it can be said that the student used an appropriate solution strategy and obtained appropriate results for the problem. Figure 3 (e)SR3 is the work of students with low-ability in math in math. They used inaccurate schematic representation. The student described sunlight as no single and in various directions so that the shadow is also less precise. Based on the result, it can be said that the student did not use the appropriate solution strategy as conducted by SR1 in Figure 3 (a) and SS4 in Figure 3 (c), namely using multiplication between 8/x and 10/15 which is not a concept of similarity in triangles. Figure 3 (f) SS5 is the work of students with moderate ability. They used inaccurate schematic representation. It can be seen in the image that the student uses line segments that are not comparable to each other. The line segment representing the length of 5m looks much shorter than the line segment representing 10m. Based on the result, it can be said that the student used an appropriate solution strategy, but there was an error in the calculation process which led to the wrong solution. Mainly, Students Chain of Thought that use inaccurate schematic representation can be described as follows:

Figure 4:
Student Chain of Thought that Using Inaccurate Schematic Representations




Based on the flowchart above, it can be seen that there are 15 students that used inaccurate schematic representations. They described objects (trees and buildings) and the distance between both objects. The things that were imperfect in the representations they made, mostly occurred when drawing lines representing sunlight (including depicting lines of light that were not straight, not single with various directions, not touching objects, cutting objects, through the back of buildings) and the size of the line segments that were far from comparable to each other.

Regarding the result of the word problem that students solved, students that use inaccurate schematic representations failed to solve the problem, as they described rays that were not straight, not single with various directions, and sunlight cutting objects. In the meantime, the types of errors were similar. It was incorrectly determining the right equation for the word problem to finish (using the multiplication sign).

Furthermore, students with low ability that used inaccurate schematic representations made inaccuracies when drawing lines representing sunlight. They drew lines that were not straight, or many lines with different directions so that the shadow was not exactly single. Meanwhile, the three SRs who used inaccurate schematic representations were unable to continue their work so they did not find a solution.

In the other hand, students with high ability who used inaccurate schematic representations, (3 out of 4 students), drew sunlight that was not straight and did not touch the object. However, it turned out to be enough to lead to finding the right solution for the problem. While 1 student, drew sunlight cutting through an object and was not yet able to formulate the right equation for the problem, hence, he or she did not find the right solution.

Meanwhile, out of 8 students with moderate ability who used inaccurate schematic representation, there were 4 found conducting incorrect solution, while the 4 rest found the correct solution. The 4 students with incorrect solution made inaccuracies by drawing the sun's rays not touching the object, cutting the

object, and drawing lines that were not comparable. However, 2 of them, fail to find the right solution by entering the wrong score or number and miscalculating. This indicates that an accurate representation is required to help understanding and avoid mistakes in understanding the word problem.

### 3. Student used pictorial representations

Of the 30 research subjects, there were 11 students who used pictorial representation. They are 6 students with medium abilities and 5 students with low abilities.

Figure 5:
The result of student's work using Pictorial Representation

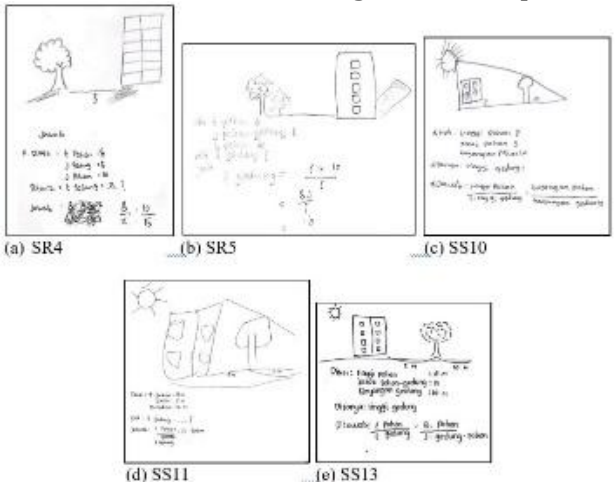
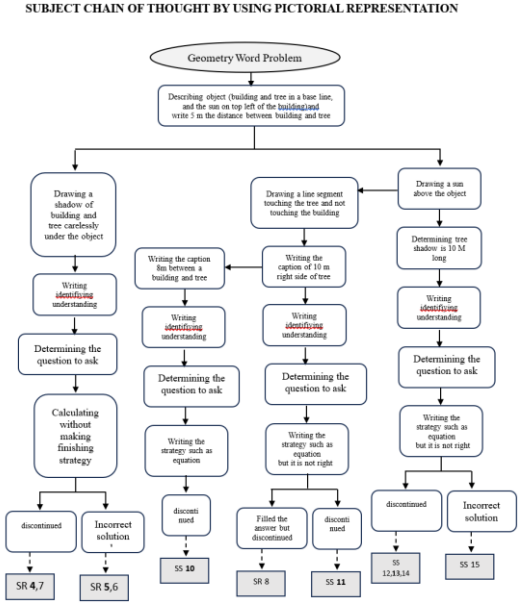



Figure 5 (a) SR4 and (b) SR5 are low-ability students that use pictorial representation. It can be seen that they describe objects in the form of buildings and trees complete with the distance between them. Furthermore, they also described the shadows of the two objects, but the shadow was drawn in the form of black shadows or similar objects, under the object, without paying attention to important information contained in the story problem related to the position of the shadow. Based on the solution, SR4 wrote the correct equation to solve the problem, but did not continue the calculation. Thus, they had not found a solution to the word problem. While SR5 solved the problem without making a strategy, which looks that the solution found was less precise. Figure 5 (c) SS10 are students with moderate ability that uses pictorial representation. They drew both objects and the sun, framing the objects in a triangle-like shape but with a non-straight line. The object is floating, not on the line drawn. Furthermore, the subject also wrote 8 under the building and 10 under the tree. The information written is not in accordance with that written in the word problem. In addition, they made an appropriate equation about similarity for the problem, but cannot give the score or number and does not continue the process, in which there is no solution to the problem. Figure 5 (d) are students with moderate ability that uses pictorial representation. It can be seen in the picture that the student only drew the sun, building, and tree and writes the distance between the building and the tree as 5 m and the length of the line to the right of the tree as 10 m, but the line segment is not connected to the ray line. The results of the solution showed that

the student is confused in applying the appropriate mathematical concept to solve this problem. In addition, they only wrote the height of the tree divided by the height of the building and multiplied by the shadow of the tree. Furthermore, the students did not finish it. Figure 5 (e) SS13 is the work result of a student with moderate ability that uses pictorial representation. It can be seen that they merely described the building, tree and sun, and adds information of 5m as the distance between the two and 10m to the right of the tree. In the solution process, the students wrote an equation related to the problem but it is not in accordance with the concept of similarity. They did not continue his answer in which there is no solution found. In general, the thought process of students who use pictorial representation can be described as follows:

Figure 6:
Student Chain of Thought that Using Pictorial Representation




Based on the flowchart above, it can be seen that all students with pictorial representation only drew objects, they are buildings and trees, as well as added 1 information about the distance between the two objects. Furthermore, there are 4 students from 5, with low ability using pictorial representation, added shadows of each object under the object randomly, for example by giving a black shadow under the object, without paying attention to the information in the story question about the position of the shadow. Meanwhile, students with moderate ability used pictorial representation, added a picture of the sun to their drawings, even though the story question did not mention the sun. However, they did not clearly show the function of the sun in their drawings. 4 out of 5 SS with pictorial representation among them, added a length of 10 m on the ground surface to the right of the tree (as a shadow), although there was no line representing sunlight so that the 10 m line segment was the shadow of the tree. While the other 2 SS added a line that touched the tip of the tree. Unfortunately, the line did not touch the building. 1 SR student also did the same thing as the last 2 SS.

This study found that, there were 4 students (13,33%) presented problems with accurate schematic representation, 15 students (50%) presented in inaccurate schematic representation, and 11 students (36.67%) presented in pictorial representation. Students that used accurate schematic representation described objects carefully and paid attention to the size, location, and distance between objects made them obtained the correct solution. Meanwhile, students that used inaccurate schematic representation, described objects (trees and buildings) and the distance between the two objects. This leads to flawed representations they made, mostly occurred once drawing lines representing sunlight (including depicting lines of light that were not straight, not single with various directions, not touching objects, cutting objects, through the back of buildings) and the size of the line segments that were far from being comparable to each other. In addition, students used pictorial representation, just drew objects in the form of buildings and trees, and only added 1 piece of information about the distance between both objects.

Looking at the results of geometry words problem solving, there were 12 students or around 40% found the right solution to solve the problem. In detail, all students with accurate schematic representation answered correctly while students with pictorial representation gave less precise solutions. Meanwhile, from 15 students that presented the problem in an inaccurate schematic representation, there are 8 of them answered correctly and 7 people answered incorrectly. From the results above, we can conclude that based on the representation made by students during they worked on math words problem, can determine the accomplishment of students in solving the word problem. This can be seen from all students that represented the schematic accurately, the answer is correct, which is in contrast to the students that used pictorial representation. Meanwhile, for students that used inaccurate representation to answer the word problem, they still have the opportunity to make mistakes in their work, see Anwar's research (2021). This state indicates that guiding students to make the right representation (accurate schematic representation) needs to be a special concern for teachers in teaching geometry problem solving in the form of word problems.

Meanwhile, in the good ability group, there were 7 students, with 4 students presented in inaccurate schematic representation and 3 presented in accurate representation. Furthermore, from 7 students, 6 of them answered the words problem correctly. There was 1 student with inaccurate schematic representation answered incorrectly, since he only compared trees and buildings. Thus, he failed to apply the concept of similarity to the word problem he had done.

Meanwhile, a group of students with moderate abilities were more diverse. There were 15 students with moderate abilities, 6 students presented pictorial representations, 8 students with inaccurate schematic representations and 1 student with accurate schematic representations. Based on the results of their problem solving, 6 students with pictorial representations did not find the right solution, while 8 students with inaccurate schematic representations, 5

answered correctly and 3 answered incorrectly. Whereas 1 student with accurate schematic representations answered the word problem correctly.

Thus, it can be said that, students with moderate abilities use inaccurate schematic presentations with inaccurate lines representing sunlight to form shadows, some are far above the object or some cut the object. Hence, the image formed is less than perfect and affects them in thinking about the correct solution. This is in accordance with the opinion of Anwar (2021) that the mixed schematic representation made by students, presents unstructured information and the schematic image formed is large which was done by students who have difficulty in understanding the information in the questions. This lead them not to get an accurate description of the problems they did.

In addition, 8 students in low-ability group, there were 5 of them presented the answer with pictorial representation and 3 of them with inaccurate schematic representation. All students in this group could not find the right solution to the problem faced. Thus, it can be said that low-ability students who use this pictorial representation were only able to describe the objects that explained in the geometry word problem, without enclosing spatial information related to the object. Hence, they were difficult to understanding the word problems they did and ends up failing to find the right solution to them.

Furthermore, this study is in line with Zakelj & Klancar (Žakelj & Klančar, 2022) that that the representation which is made by student to solve a problem can help them in the process of understanding the word problem, which lead to choosing the appropriate solution strategy. This can be seen from the representation formed correctly by the subject will direct them to the right solution. Furthermore, the results of this study are also in line with the results of research by Garderen (2003) and Hegarty (1999) which stated that the use of schematic spatial representations is positively correlated with solving mathematical problems. However, there is a slightly significant negative correlation between the use of pictorial representations and solving mathematical problems. This means that schematic representations include spatial relation can solving a word problem, while pictorial representations include details that are not relevant to solving the problem. Hence, the results of this study are also in line with Rohmatin's research (2024) which also reveals that in geometric proof problems, student success is mainly determined by the quality of the visual representations they make, as well as the accuracy in choosing a visualization strategy.

## CONCLUSION

The results of this study are significant since they provide a factual portrait of how junior high school students represent visual information in the context of solving geometric words problems. These findings reveal that the majority of students have not been able to make accurate visual representations schematically, which is an important skill in understanding spatial and geometric concepts in depth. Hence, this emphasizes the need to strengthen visualization-based learning in mathematics, particularly

building students ability to describe geometric situations proportionally, precisely, and in accordance with geometric principles. This will lead the teachers to design more effective learning approaches, such as providing systematic schematic drawing exercises, using scheming or digital media, and integrating spatial exploration into problem-solving activities. Further research is recommended to explore learning interventions to improve students' visual representation skills, such as the use of visualization technology or project-based learning approaches. In addition, further research can also map the relationship between the type of visual representation and the level of achievement in solving geometric problems, as well as explore the cognitive and affective factors that influence the choice of representation. It is also necessary to expand the scope of students from various school backgrounds and grade levels to obtain a more comprehensive picture and stronger generalization.

The conclusion section contains a summary of the research findings, which correlate with the research objectives written in the introduction. Then state the main points of the discussion. A conclusion generally concludes with a statement about how the research work contributes to the field of study as a whole (shows how progress from the latest knowledge). A common mistake in this section is to repeat the results of an experiment, abstract, or be presented with a very list. The concluding section must provide clear scientific truths. In addition, the conclusions can also provide suggestions for future experiments.

## REFERENCES

Afriyani, D., Lukito, A., & Khabibah, S. (2019). Students' Construction Error in Translation Among Mathematical Representations. *Journal of Physics: Conference Series*, *1157*(3), 032026. https://doi.org/10.1088/1742-6596/1157/3/032026

Aini, N. R., Susanto, S., Yudianto, E., Wijaya, H. T., & Cahyanita, E. (2021). The development of geometry test to analyze students' creative thinking skills in the area of square formula derivation. *Journal of Physics: Conference Series*, *1836*(1). https://doi.org/10.1088/1742-6596/1836/1/012050

Anwar, R. B. (2020). Translation of Mathematical Representation: Characteristics of Verbal Representation Unpacking. *Journal of Physics: Conference Series*, *1470*(1), 012014. https://doi.org/10.1088/1742-6596/1470/1/012014

Anwar, R. B. (2021). Effectiveness of Schematic Representation in Solving Word Problems. *Jurnal Pendidikan Matematika Indonesia*, *6*(1), 54–63.

Anwar, R. B., Purwanto, P., As'Ari, A. R., Sisworo, S., & Rahmawati, D. (2019). The process of schematic representation in mathematical problem solving. *Journal of Physics: Conference Series*, *1157*(3). https://doi.org/10.1088/1742-6596/1157/3/032075

Boonen, A. J. H., Van Wesel, F., Jolles, J., & Van der Schoot, M. (2014). The role of visual representation type, spatial ability, and reading comprehension in word problem solving: An item-level analysis in elementary school children. *International Journal of Educational Research*, *68*, 15–26. https://doi.org/10.1016/j.ijer.2014.08.001

Council of Teachers of Mathematics, N. (n.d.). *Principles Standards and for School Mathematics*.

Duval, R. (2006). A cognitive analysis of problems of comprehension in a learning of mathematics. *Educational Studies in Mathematics*, *61*(1–2), 103–131. https://doi.org/10.1007/s10649-006-0400-z

Goldin, G. A. (1998). Representational Systems, Learning, and Problem Solving in Mathematics. *JMB JOURNAL OF MATHEMATICAL BEHAVIOR*, *17*(2), 137–165.

Hegarty, M., & Kozhevnikov, M. (1999). Types of Visual-Spatial Representations and Mathematical Problem Solving. In *Journal of Educational Psychology* (Vol. 91, Issue 4).

Jitendra, A. K., & Woodward, J. (2019). The Role of Visual Representations in Mathematical Word Problems. In *Cognitive Foundations for Improving Mathematical Learning* (pp. 269–294). Elsevier. https://doi.org/10.1016/B978-0-12-815952-1.00011-6

Pape, S. J. (2001). The Role of Representation(s) in Developing Mathematical Understanding. *Mathematical Thinking and Learning*, *3*(1), 1–6. https://doi.org/10.1207/S15327833MTL0301_1

Rahmania, L., Pambudi, D. S., & Kurniati, D. (2024). Development of Mathematics Learning Tools Based on Education for Sustainable Development (ESD) Using the Outdoor Learning Mathematics Method to Enhance Mathematical Connections in Junior High School. *International Journal of Current Science Research and Review*, *07*(07). https://doi.org/10.47191/ijcsrr/V7-i7-58

Rohmatin, E. (2024). Student Representation in Solving Geometric Proof Problem. *Journal of Mathematics Learning Innovation*, *10*(1), 1–12.

Van Garderen, D., & Montague, M. (2003). Visual-Spatial Representation, Mathematical Problem Solving, and Students of Varying Abilities. In *Learning Disabilities Research & Practice* (Vol. 18, Issue 4).

Yudianto, E., Sunardi, Sugiarti, T., Susanto, Suharto, & Trapsilasiwi, D. (2018). The identification of van Hiele level students on the topic of space analytic geometry. *Journal of Physics: Conference Series*, *983*(1). https://doi.org/10.1088/1742-6596/983/1/012078

Zahner, D., & Corter, J. E. (2010). The process of probability problem solving: Use of external visual representations. *Mathematical Thinking and Learning*, *12*(2), 177–204. https://doi.org/10.1080/10986061003654240

Žakelj, A., & Klančar, A. (2022). The Role of Visual Representations in Geometry Learning. *European Journal of Educational Research*, *11*(3), 1393–1411. https://doi.org/10.12973/eu-jer.11.3.1393