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# Level of visual geometry skill towards learning style Kolb in junior high school

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## Abstract

This study aims to conduct an in-depth analysis of the visual thinking level of junior high school students with the learning style of assimilators, converges, accommodators, and divergers in solving geometry problems. The type of research used is qualitative research with a grounded theory and case study design. The subjects studied were junior high school students consisting of 6 of 56 students. Data were collected through a learning style inventory (LSI) test given to 56 students to group participants based on the learning style of the Kolb model, then a geometry problem-solving test and interviews were given to 6 students, namely two assimilator students, one converges, one accommodator, and two diverger students. The analysis is based on data from written test results and interviews. Then, time triangulation is carried out to obtain valid research data. The analysis was conducted based on data from written test results and interview results paired with video recordings. Then, triangulation of time is carried out to obtain valid research data. The results of the analysis showed that assimilator students and converger students were able to achieve at the global visual level, namely being able to carry out visual thinking activities well in solving problems, illustrate the problem correctly in geometric drawings/objects, represent problems in mathematical symbols precisely and can express relationships between images well. While accommodator and diverger students can only reach the local visual level, they have yet to be able to show every visual thinking activity well in solving geometry problems, illustrating problems in geometry drawings that could be more precise, and solving rudimentary geometry problems.

**Keywords:** global visual; learning style; local visual; problem-solving; visual thinking level

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## Introduction

Thinking is a mental activity; according to Santrock (2007), thinking is a process of manipulating information in memory. Solso and Maclin (2007) define thinking as the result of mental representation through transforming information in a person. Sternberg (2008) explains that information obtained by a person can be represented in two forms of ciphers: verbal and visual. This is called the double encoding theory. The information in the form of verbal ciphers and visual ciphers represented in abstract propositions is called prepositional-conceptual theory. So, forming visual information in the mind is called visualization or visual thinking.

Arcavi & Weizmann (2003) define visual thinking as an ability or process, interpretation, or ideas about tables, pictures, or diagrams that are in mind, then expressed on paper or using technological tools. Wileman (in Stokes, 2002) defines visual thinking as a person's ability to change all kinds of information in his mind into graphs, tables, pictures, diagrams, or other forms so that it can assist in communicating that information. So, visualization and visual thinking is a thinking ability that changes verbal statements into images, pictures, and graphics. Participants who learn without using visual thinking are more likely to make mistakes and visual thinking images help students solve problems requiring a high level of reasoning. As a result, visual thinking is critical to successful learning (Lee et al., 2021; Sumarni & Prayitno, 2016). There are seven essential roles of visual thinking in learning mathematics, namely: as an alternative to calculations, simplifying problems, as a tool for checking solutions (visualization can be used to verify the correctness of the solutions obtained), modeling problems into the form of mathematical statements, to understand problems, to find connections with related problems easily, and as suggestions to meet individual learning styles (Kang & Liu, 2018; Presmeg, 2006).

According to Huang (2013), visual thinking has become an exciting field for some researchers who care about mathematics education, so many researchers emphasize the importance of visual thinking in understanding and constructing mathematical concepts. In addition, given that many researchers have previously found that students experience limitations and difficulties due to using incorrect visual representations, visual thinking is also interesting to discuss. Students need help understanding problems, drawing diagrams correctly, reading graphs, understanding formal mathematical concepts, and solving mathematical problems (Arcavi & Weizmann, 2003; Eisenberg, 1994; Herizal et al., 2019; Kadunz & Yerushalmy, 2015).

In visual thinking, a person has a level of thinking. This aligns with the results of Huang's research of 15 participants then grouped into three levels of visual thinking to understand the concept of infinite integrals (Huang, 2013). The three levels are non-visual, local visual, and global visual. However, Ali (2017) sees a prospective teacher's visual thinking level in understanding the formal definition of a row of real numbers based on five stages: recognizing, imagining, showing definitions, showing definition attributes, and concluding. As opposed to that, MOE (2001), a person, when thinking visually in solving mathematical problems, goes through the following stages: understanding the relationship of spatial elements in the problem, explaining the interrelationship of concepts with each other in solving problems; constructing or constructing a visual representation; using visual representation to solve problems; and finding solutions to problems.

Geometry is a branch of mathematics that requires visual thinking to understand concepts and solve mathematical problems. According to Hoffer (1981), five basic geometry skills must be discussed and considered at the high school level: drawing, verbal, visual, applied, and logic skills. There is another reason why geometry should be studied, namely: understanding the world around us becomes easier with geometry, learning about geometry can help children learn to solve problems, geometry has a significant meaning and has an impact on other areas of mathematics, geometry is widely used in everyday life (Van de Walle, 2004).

However, the reality is that many Indonesian students still need help solving geometry problems. Some research results report that junior high school students have difficulty understanding the concepts of plane figures, limitations in solving contextual geometry problems, and difficulty concluding deductively (Anwar et al., 2022; S. Z. Sholihah & Afriansyah, 2018; Yuan, 2013; Yuwono, 2016). On the other hand, some research results also report that students have difficulty translating geometry problems into mathematical models, establishing appropriate procedures or strategies, and performing correct calculations (Jalinus et al., 2020; Rokhima et al., 2019; Wijayanti et al., 2017). Students need help solving problems due to errors in illustrating problems into mathematical models or drawings, establishing the correct formulas or procedures, and performing incorrect calculations (Culaste, 2011; Wu & Adams, 2006).

Although visual thinking should undoubtedly play an important role in mathematical activity, it is necessary to conduct research that helps to understand more about its features that contribute significantly to the role in a particular mathematical situation. Much research focuses on visual thinking but needs to include more on the level of visual thinking, especially at the high school level. This research differs from other studies because it expands the understanding of students' difficulties and strengths associated with visual thinking. It identifies the levels of visual thinking they use when solving geometry problems.

Someone solving geometry problems will involve visual thinking, but the visual thinking process differs between students. However, each child's different understanding and processing of information cause differences in their thought processes. This difference is a person's "learning style, " defined as their preference for learning processes or activities. Vermunt (1992) defines *learning style* as a process of cognition and affection for the material, mental learning models, and learning orientation. According to (Beaty et al., 1997), learning orientation can be understood as a comprehensive domain that includes individual goals, intentions, motives, expectations, attitudes, and interests regarding the learning process. James & Gurdner (1995) defines "learning styles as the complex manner and conditions under which learners perceive, process, store, and recall what they are attempting to learn most efficiently and most effectively" They assume that understanding, processing, storing, and remembering what they are trying to learn most efficiently and most effectively.

Keefe (in Young, 2010) defines *learning style* as A characteristic of cognitive, affective, and psychological behaviors that are relatively stable indicators of how learners perceive, interact with, and respond to the learning environment". Learning styles are cognitive, affective, and behavioral characteristics of psychology that are relatively stable, indicating how learners feel and interact with the learning environment. Other experts also define learning styles as how learners begin to concentrate, process, absorb, and contain new and complex information, then organize and manage information (DePorter & Hernacki, 2000; Kolb, 1984; Santrock, 2007).

Kolb (1984) states that one can change experiences through reflective observation and active experimentation. Thus, Kolb et al. (2000) shares types of learning styles based on concrete experience, abstract concepts, reflective observations, and active experiments, namely diverger (concrete experiences and reflective observations), accommodators (concrete experiences and active experiments), assimilators (abstract concepts and reflective observations), and converges (abstract concepts and active experiments).

Based on this, the author is interested in studying the problem of the visual thinking level of junior high school students in solving geometry problems in terms of the Kolb Model Learning Style through scientific research. The problem in this study was formulated as research questions: How does the description of the level of geometric visual thinking of junior high school students in solving geometry problems in terms of the learning style of the Kolb model?

## Methods

This research uses a qualitative approach with a grounded theory and case study design. The case study explores "a case/variety of cases" that, over time, provides a detailed picture of a context through in-depth data collection and involving various sources of information (Cohen et al., 2007; Creswell, 2015). Researchers choose to use case study design because researchers want to explore in depth and detail the subject to be studied using various procedures to collect and answer researcher questions.

This study was conducted on 20 male and 36 female grade IX students. Of the 56 students, researchers grouped students into categories of assimilator with SA code, accommodator with SM code, converger with SC code, and diverger with SD code. Furthermore, the instruments used in this study are learning style inventory (LSI) instruments used to obtain student learning styles and geometry problem-solving test instruments (GPST) used to obtain an overview of visual thinking levels. Data in this study were obtained through LSI tests, geometry problem-solving tests, and interviews. Interviews were conducted while participants solved geometry problems and recorded using video recordings. The results of the interview will be transcribed using NVIVO Mac 12 Pro. The geometry problem in question is as follows:

*"Assume the $PQRS$ is a plan ffigurea length of $PQ = 7\ cm$ and $QR = 25\ cm$. Point $T$ is an extension of the $RS$ line, such that it is $TP \perp RT$ in $T$. If the length is $RT = 22\ cm$, then determine the area of the $PQRT$ flat build. How do you get it?"*

Furthermore, the data is analyzed through open, axial, and selective coding using qualitative data processing software NVIVO Mac 12 Pro. This is in line with the opinion of Mile et al. (2014) that there are three stages in qualitative data analysis during and after the data is collected: the data reduction stage, the data display stage, and the conclusion-drawing stage. These stages can be seen in the following Figure 1.

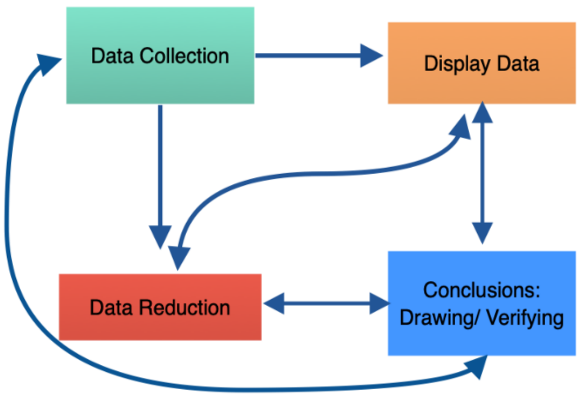


**Figure 1.** Qualitative analysis phase of the Miles & Huberman data model

The level of visual geometry skill used is the level of visual thinking adapted from Huang, which can be seen in the table below:

**Table 1.** Visual thinking level in solving geometry problems (Anwar & Juandi, 2020)

| Geometry visual thinking level | Characteristics |
|---|---|
| Level 0: Non-Visual (NV) | Students do not involve visual thinking activities in solving geometry problems; Students tend to solve geometry problems by using symbolic representations; Students solving geometry problems are still in the category of invalid; Students need to be more precise in illustrating/painting problems into geometric drawing shapes. |
| Level 1: Local Visual (LV) | Students already involve visual thinking; Students have not been able to distinguish the relationship between several images in geometry; Students use symbolic representations correctly; Students can solve geometry problems; Students have not been entirely correct in illustrating/painting the problem into geometric drawings. |
| Level 2: Global Visual (GV) | Students are already involved in visual thinking: They can distinguish the relationships between images, begin to recognize the traits they observe, and can already name the regularities contained in the images they make or observe. Students are already using symbolic representations correctly; Students solve geometry problems correctly; Students can illustrate/paint problems into geometric drawing shapes correctly. |

## Results

The open coding stage is the stage in coding students' answers and interview transcripts related to visual thinking when solving geometry problems. The identification process refers to the central phenomenon that the researcher has established at the beginning of the analysis. The focus of the study led to the formation of conjectures that linked the characteristics of the visual thinking level and Kolb's learning style. From this central phenomenon, the researcher examines a series of actions and interactions of students in solving geometric problems. Furthermore, researchers drew on the underlying themes identified in the data and used them to establish the characteristics of the visual thinking level.

### Open coding

Here is an open coding presentation to find categories based on students' visual thinking levels in solving geometry problems.

**Thema 1**: Coaching visual thinking activities in solving geometry problems

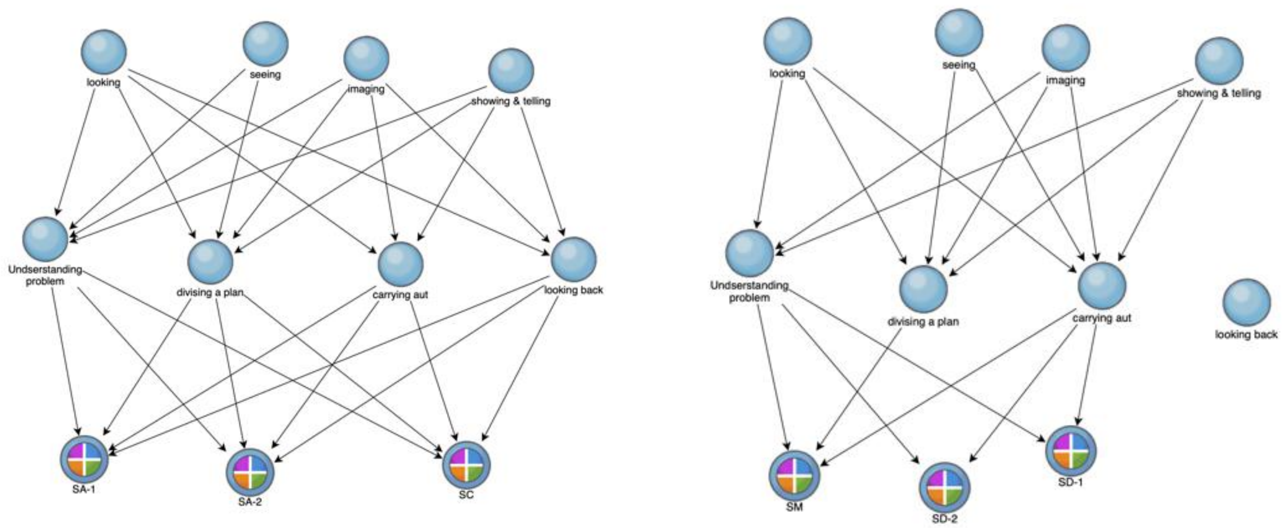


**Figure 2.** Visualization of student visual thinking activities

Based on the results of the analysis of GPST test answers and interviews related to visual thinking of assimilator, accommodator, diverger, and converges students in solving geometric problems, there are similarities in visual thinking activity patterns (looking, seeing, imaging, showing, telling) in each Polya problem solving so that two categories are obtained that explain theme 1, namely, all activities and some activities. The following will be presented visual thinking activities of each participant in solving geometry problems:

Based on the figure above, Figure 3 shows the visual thinking activity of the assimilator and converges students in solving geometry problems. The three students, SA-1, SA-2, and SC, can show every visual thinking activity or the stages of looking, seeing, imaging, showing, and telling at each stage of solving Polya's problems. Meanwhile, SM can show every visual thinking activity at the stage of understanding problems, compiling problem-solving plans, and carrying out problem-solving. Then, SD-1 and SD-2 can only show visual thinking activities to understand the problem and implement the problem-solving plan. Thus, accommodator and diverger students cannot show every visual thinking activity in solving geometry problems.

**Theme 2:** Illustrating the problem in geometric objects

Based on the analysis of the answers and transcripts of interviews related to the visual thinking of assimilator, accommodator, diverger, and converger students in solving geometric problems, there are similar patterns in illustrating problems into pictures, so two categories are obtained that explain the theme 2, namely understanding the problem and understanding concepts. The following will present the findings on illustrating the problem in the shape of a geometric object:


**Figure 3.** Illustration of the problem from SC and SA-1

In the image above, SA-1 correctly illustrated the problem and labeled the things in the picture. This shows that SA-1 can already understand the situation well and understands the concept of quadrilaterals and the concept of two perpendicular lines. Likewise, with SC, it appears in Figure 3 that SC has illustrated the problem correctly because SC also understands the situation precisely and understands the concept of four and two perpendicular lines.

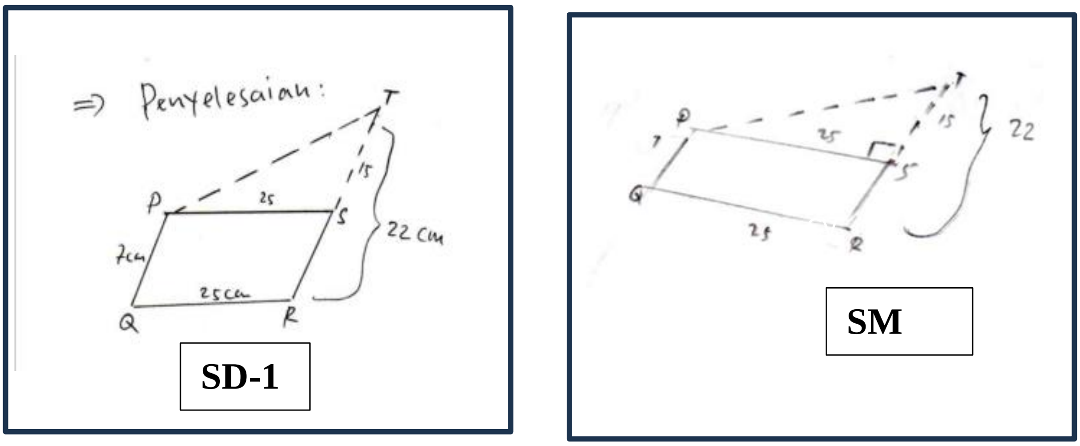


**Figure 4.** Illustration of the problem from SD and SM

Unlike the SA-1 and SC, Figure 4. above shows that SD-1 and SM incorrectly illustrate the problem in geometry images. This is because SD-1 and SM have yet to understand the problem and the concept of two perpendicular lines correctly.

**Theme 3: Solving geometry problems**

Based on the analysis of answers related to visual thinking of assimilator, accommodator, diverger, and converger students in solving geometry problems, there are similar patterns in solving geometry problems, so two categories are obtained that explain theme 3, namely understanding concepts, strategies, and arguments.

*Arguments*

*P :* *Why use the Pythagoras formula?*

*SA-1:* *Because to solve this problem requires the length of the PT, which is the height of the trapezoid. Then PTS is a right triangle, so the Pythagoras formula applies.*

*P:* *What does the PTS triangle have to do with the PQRT trapezoid?*

*SA-1* *The height on the PTS right triangle is also the height of the PQRT trapezoid. In addition, the combination of the PTS triangle and the PQRS parallelogram is the area of the PQRT trapezoid.*

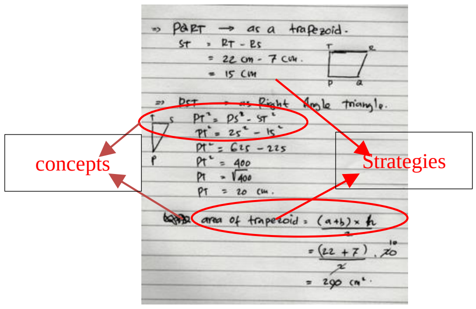


**Figure 5. Solving geometry problems from SA-1**

To solve these problems, SA-1 can set the right strategy and be able to provide appropriate arguments. Based on Figure 5. That SA-1 mentions the trapezium area formula correctly to solve it precisely. Besides solving correctly, SA-1 can offer ideas at every step, such as explaining Pythagoras procedures. So that SA-1 can be declared capable of understanding concepts, naming strategies, and providing arguments correctly. The same thing happened with SC, but SC used a different formula to solve the problem. Here is SC's overview of solving the problem.

*Arguments*

*P :* *Why use this strategy?*

*SA-1:* *From the figure, the area of the PQRT trapezium is the sum of the PTS triangle area and the PQRT parallelogram area.*

*P:* *What does the PTS triangle have to do with the PQRT trapezoid?*

*SA-1* *The height on the PTS right triangle is also the height of the PQRT trapezoid. In addition, the combination of the PTS triangle and the PQRS parallelogram is the area of the PQRT trapezoid.*

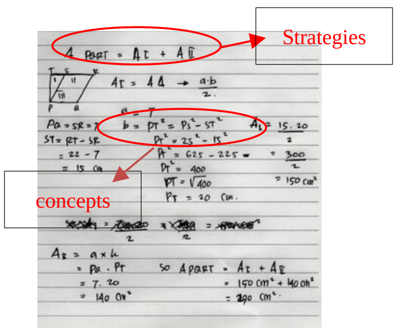


**Figure 6.** Solving geometry problems from SC

It is based on Figure 6. In solving the problem, SC uses a different strategy from SA-1, where SC sets a plan to find the area of the PQRT trapezium by summing the area of the PTS triangle and the site of the PQRT parallelogram. Then, SC can provide arguments on each step it uses, such as explaining the use of the PQRT trapezium area strategy by summing the area of the PTS triangle and the site of the PQRT parallelogram. This shows that SC understands the concepts of quadrilaterals and triangles very well.

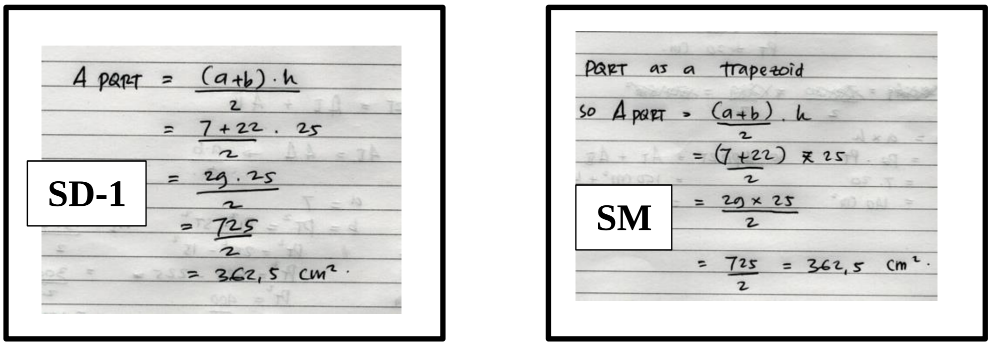


**Figure 7.** Solving geometry problems from SM

Figure 7 shows that SD-1 set an improper strategy in solving the above problems. SD-1 establishes the PQRT area formula, which is the trapezoidal area formula, but the elements used in the trapezoidal area formula are not precise, so an invalid solution is obtained. In addition, it was also found that SD did not yet understand the concepts applied in the strategy. BC did the same thing: establishing an improper strategy despite correctly applying the trapezoid area formula.

## Axial coding

At the axial coding stage, researchers select the main categories obtained at the open coding stage to be used as a core category as a central phenomenon in developing theories. Three themes build the characteristics of the level of visual thinking in solving geometry problems, namely doing visual thinking activities in solving geometry problems, illustrating problems into geometric objects, and solving geometric visual thinking problems, which are used as central phenomena and then related to other categories them. These other categories are causal conditions.

Corbin and Strauss (1990) state that causal conditions influence central phenomena. These causal conditions include looking, seeing, imagining, showing and telling, reading, understanding problems, and visualization. These conditions affect students' visual thinking in solving geometry problems.

The core category / central phenomenon is the characteristic level of visual thinking built by four themes: carrying out visual thinking activities in solving geometry problems, representing problems using mathematical symbols, recognizing relationships between geometric images/objects, and solving geometric visual thinking problems. Strategies are actions taken in response to central phenomena, which in this study are: quadrangular flat build concept, triangle flat build concept, parallelogram flat area, trapezoidal flat build area, Pythagorean concept, awakening, congruence, the concept of two parallel lines and the concept of two perpendicular lines.

Context and intervening conditions are specific and general situational factors that influence strategy. In particular, the context conditions in the findings of this study include the area of the parallelogram flat build and the area of the trapezoidal flat build. In general, the intervening conditions in this finding are mastery of concepts, problem-solving, learning styles, and learning experiences.

Consequences are nothing that arises with the application of consequence strategies produced in this study in the form of junior high school students with accommodator and diverger learning styles at the local visual level, while assimilator and converger students are at the global visual level. Furthermore, the following process in selective coding is carried out from the axial coding diagram. An axial coding diagram is presented in the following figure:

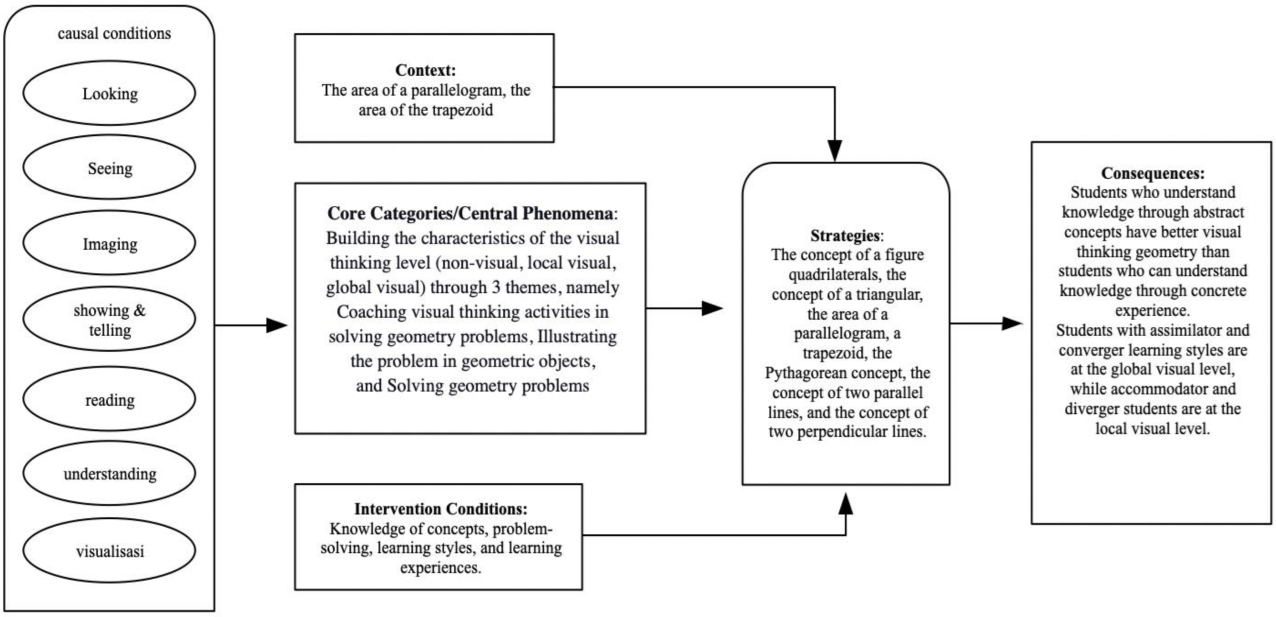


**Figure 8.** Axial coding diagram

**Selective coding**

In the selective coding stage, the researcher writes a theory of the interrelated categories in the axial coding model. At a basic level, this theory provides an abstract explanation for the process being studied in this study. It integrates and refines theory (Strauss & Corbin, 1998) by writing down storylines that link categories and tracing personal memos about theoretical ideas.

At this stage, the researcher builds and generates hypothetical conclusions. The whole procedure (open coding, axial coding, and selective coding) leads to the emergence of a theory based on the data collected by the researcher. The theory of grounded theory research is an abstract explanation or understanding of a process related to substantive topics based on data, so the theory cannot have a broad scope. However, neither is it hypothetical of minor work (Glaser & Strauss, 1967), but rather, the resulting theory is middle range (still talkable) (Charmaz, 2000).

Based on the findings and data analysis of student answers and interviews related to the level of visual thinking that has been analyzed through the stages of open coding, axial coding, and selective coding, it was found that the characteristics of this level of visual thinking are:

- Carrying out visual thinking activities in solving geometry problems;
- Illustrating problems in the form of geometric objects;
- Solving geometric problems;
- Representing problems in the form of mathematical symbols;
- and being able to show Relationships between images.

The theoretical model produced in building the characteristics of students' visual thinking levels in solving geometry problems obtained hypothetical conclusions, namely:

**Hypothetical conclusion**: "Students who can understand knowledge through abstract concepts have better geometric visual thinking than students who can understand knowledge through concrete experience."

## Discussion

Based on the results of the data analysis that has been carried out, the picture of the visual thinking level of assimilator, accommodator, diverger, and converger students in solving geometric problems is as follows:

### Level visual thinking geometry assimilator students

Based on the presentation of visual thinking findings of assimilator students in solving geometry problems, SA-1 and SA-2 have involved visual thinking activities or steps, namely looking, seeing, imaging, and show and telling in each phase of solving Polya problems. It can then enumerate the relationships between the images it observes and recognize their properties, such as explaining the relationship of the plane figure of the PQRS parallelogram with the PST triangle and the PQRT trapezoid. In addition to recognizing the relationships between images, SA-1 and SA-2 can recognize related concepts in the image to solve given problems, such as the Pythagorean concept, the plane figure, and the concept of two perpendicular lines. Regarding mathematical symbols, SA-1 & SA-2 already use mathematical symbol representations in solving geometry problems. However, at the stage of understanding the problem (grouping information based on known and questionable things), they do not show the representation of mathematical symbols.

The picture of the visual thinking level of SA-1 and SA-2 assimilator students in solving geometry problems tends to be at level 2, namely global visual (GV). That is, students are involved in visual thinking activities in solving problems, can relate relationships between the images they observe and recognize their properties and related concepts to find solutions to problem-solving, illustrate problems in the form of geometric objects correctly, solve geometry problems by applying the right strategy and obtaining a correct solution. The statement of A supports this, Kolb & Kolb (2005) and Kolb (2014) that individuals with an assimilator learning style analyze something abstract, solve problems logically, step by step, and conclude at the end of the solution. Moreover, in line with the results of the research of Wicaksono et al. (2021), students with an assimilator style can carry out the solution plan well and explain it logically. The results of this study are supported by the results of research conducted by previous researchers, that students who have visual thinking skills at the global visual level can use graphic representations and symbolic representations correctly in solving problems, able to recognize the relationship between the image and related concepts and solve the problem validly (Anwar & Juandi, 2020; Huang, 2013; Sholihah et al., 2016).

**Level visual thinking geometry converges students.**

Based on the presentation of visual thinking findings, students converge in solving geometry problems. SC can involve visual thinking activities or steps, namely looking, seeing, imaging, and showing and telling in each phase of solving problems (Polya, 1973). It can then enumerate the relationships of the plane figure of the PQRS parallelogram with the PST triangle and the PQRT trapezoid. In addition to recognizing the relationships between images, SC can also recognize related concepts in the image to solve given problems, such as the Pythagorean concept, the broad concept of plane quadrilaterals and triangles, and two perpendicular lines.

Thus, it can be said that the picture of the level of visual thinking of converge students (SC) in solving geometric problems tends to be at level 2, namely global visual (GV); that is, students have involved visual thinking activities in solving problems, can relate relationships between the images they observe and recognize their properties and related concepts to find solutions to problem-solving, use symbolic representations correctly in solving problems, illustrating images and finding the right problem-solving solutions and being able to explain them logically. This is in line with the results of research conducted by Huang (2013) and U. Sholihah et al. (2016), which show that students who have visual thinking skills at the global visual level can use graphical representations and symbolic representations correctly in solving problems; able to recognize the relationship between images and related concepts and solve problems validly.

**Level visual thinking geometry accommodator students**

Based on the presentation of visual thinking findings of accommodator students in solving geometry problems, SM has not been fully involved in visual thinking activities or steps, namely looking, seeing, imaging, and show and telling in each phase of solving problems Polya (1973) as discussed in the visual thinking findings of accommodator students above, namely SM is only able to perform visual thinking steps at the stage of understanding the problem, devising a plan, and carrying out the plan. Unlike the stage of looking back, the steps of visual thinking cannot be shown perfectly because, at this stage, the accommodator student does not look back. This is in line with the research of Riau & Junaedi (2016) and Wicaksono et al. (2021) that individuals with an accommodator learning style cannot show a confident attitude towards the solution they get because they do not look back.

Thus, it can be said that the picture of the visual thinking level of accommodator (SM) students in solving geometry problems tends to be at level 1, namely local visual (LV); that is, students have not fully involved in visual thinking activities in solving problems; has not been able to fully relate the relationships between the images it observes and recognize its properties and related concepts to find solutions to solving problems; has not been entirely precise in using symbolic representations to solve problems; and rudimentary in illustrating the problem into the form of geometric drawings. This is in line with the results of research conducted by Huang (2013) and U. Sholihah et al. (2016), which show that students who have visual thinking skills at the local visual level have the following characteristics, have not been able to fully use graphic representations and symbolic representations correctly in solving problems; has not been able to fully recognize the interrelationships between images and related concepts and validly solve the problem.

### Level visual thinking geometry diverger students

Based on the presentation of visual thinking findings, students diverger in solving geometry problems that SD-1 and SD-2 have yet to involve visual thinking activities fully or steps, namely looking, seeing, imaging, and show and telling in each phase of solving Polya (1973) problems. From the presentation of the visual thinking findings of the diverger students above, SD-1 can only carry out visual thinking steps at the stage of understanding the problem, devising a plan, and carrying out the plan. In contrast, Different from looking back, the steps of visual thinking cannot be shown perfectly because, at this stage, the diverger student needs to look back and re-examine. This is in line with the research of Riau & Junaedi (2016) and Wicaksono et al. (2021) that individuals with diverger learning styles can only carry out problem-solving activities up to the stage of implementing a problem-solving plan. Still, only some of the solutions are correct.

## Conclusion

Based on the presentation of the results of this study, assimilator students and converger students were able to achieve at the global visual level (GV), namely being able to carry out visual thinking activities well in solving problems, illustrate the problem correctly in geometric drawings/objects, represent problems in mathematical symbols precisely and can express relationships between images well. While accommodator and diverger students can only reach the local visual level (LV), they have yet to be able to show every visual thinking activity well in solving geometry problems, illustrating problems in geometry drawings that could be more precise, and solving rudimentary geometry problems. The theoretical model produced in building the characteristics of students' visual thinking levels in solving geometry problems obtained hypothetical conclusions: "Students who can understand knowledge through abstract concepts have better geometric visual thinking compared to students who can understand knowledge through concrete experience."

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## Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, misconduct, data fabrication and falsification, double publication and submission, and redundancies, have been completed by the authors.


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## Author Contributions

**Anwar:** Conceptualization, writing - original draft, editing, and visualization; **Turmudi, Dadang Juandi:** Writing - review & editing, formal analysis, and methodology; **Saiman and Muhammad Zaki:** Validation and supervision.

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