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Level of Visual Thinking Junior High School Students in Solving Geometry Problems: A Study Grounded Theory

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Abstract (12-point, bold)

The purpose of this study is to conduct an in-depth study of the visual thinking level of junior high school students who have the learning style of assimilators, converges, accommodators and diverger in solving geometry problems. The type of research used is qualitative research with a grounded theory design. The subjects studied were junior high school students consisting 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 2 assimilator students, 1 converge student, 1 accommodator student and 2 diverger students. The analysis is carried out on the basis of data on the results of written tests and the results of interviews. Then time triangulation is carried out to obtain valid research data. The analysis results show that assimilator and converge students can reach the global visual level. In contrast, accommodator and diverger students can only reach the local visual level. Grounded theory analysis results in a theoretical formulation that students who understand knowledge through abstract concepts have better visual thinking geometry than students who can understand knowledge through concrete experience.

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

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Introduction

Thinking is a mental activity; according to Santrock (2007) thinking is a process of manipulating information in memory. Solso & Maclin (2007) defines thinking as the result of mental representation through the transformation of information in a person. Sternberg (2008) explains that information obtained by a person can be represented in two forms of cyphers: verbal and visual. This is called the double encoding theory. The information in the form of verbal cyphers and visual cyphers represented in abstract propositions is called a prepositional-conceptual theory. So, the process of forming visual information in 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 important 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), to model problems into the form of mathematical statements, to easily understand problems, to find connections with related problems, and as suggestions to meet individual learning styles (Kang & Liu, 2018; Presmeg, 2006).

According to Huang (2013), visual thinking has become an interesting 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 have difficulty 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).

Geometry is one of the branches of mathematics that require visual thinking to understand concepts and solve mathematical problems. According to Hoffer (1981), five basic geometry skills need to be discussed and considered in depth 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 figure, 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 valid calculations (Jalinus et al., 2020; Rokhima et al., 2019; Wijayanti et al., 2017). Factors that make students have difficulty in solving problems are errors in illustrating problems into mathematical models or drawings, establishing the right formulas or procedures and performing incorrect calculations (Culaste, 2011; Wu & Adams, 2006).

Although visual thinking should certainly 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 little 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 is different between one student and another. However, the different understanding and processing of information in each child cause differences in their thought processes. This difference is known as 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.

D. A. Kolb, (1984) states that one can also change experiences in two ways: reflective observation and active experimentation. Thus, D. A. 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 visual thinking 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 is the visual thinking level of junior high school students in solving geometry problems reviewed in learning styles?

Literature Review

1. Visual Thinking Level

In visual thinking, a person has a level or level of thinking. This is in line 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 the level of visual thinking of a prospective teacher 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: 1) Understanding the relationship of spatial elements in the problem; 2) Explain the interrelationship of concepts with each other in solving problems; 3) Constructing or constructing a visual representation; 4) Using visual representation to solve problems; 5) Finding solutions to problems.

In this case, the level or level of visual thinking described by Ali (2017) and MOE (2001) above is the stage that a person goes through when thinking visually in solving mathematical problems so that the characteristics based on each of these stages the author puts in the visual thinking level indicator. Thus, the author builds an indicator of the level of visual thinking in solving geometric problems adapted from the level of visual thinking according to Huang (2013) can be seen in the following table:

Table 1. Visual thinking level in solving geometry problems

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 the form of geometric drawings.
Level 2: Global Visual (GV)	Students already involved in visual thinking; They student can distinguish the relationships between images, begin to recognize the traits he observes, is already able to name the regularities contained in the images he makes or observes; Students are already using symbolic representations correctly; Students solve geometry problems correctly; Students can

Geometry visual thinking level	Characteristics
	illustrate/paint problems into geometric drawing shapes correctly.

(Anwar & Juandi, 2020)

2. Learning Styles

Keefe (in Young, 2010) defines *learning style* as "A characteristic of cognitive, affective, and psychological behaviors that serve as 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 the way learners begin to concentrate, process, absorb, and contain new and difficult information, then organize and manage information (DePorter & Hernacki, 2000; D. A. Kolb, 1984; Santrock, 2007)

D. A. Kolb (1984) shares a person's learning style based on experiential learning, which involves concrete experience, reflective observation, creating concepts and using theory to solve problems (abstract conceptualization), and learning through action or experimentation (active experimentation). A person can understand knowledge in two ways: concrete experience and abstract concepts. Then one can also change the experience in two ways, through reflective observation or active experimentation. So based on these learning experiences, D. A. Kolb (2014) shared four types of learning styles, namely converges (abstract concepts and active experiments), diverger (concrete experiences and reflective observations), assimilators (abstract concepts and reflective observations), and accommodators (concrete experiences and active experiments). The relationship between learning experience and type of learning style Kolb can be seen in the form of the following quadrants:

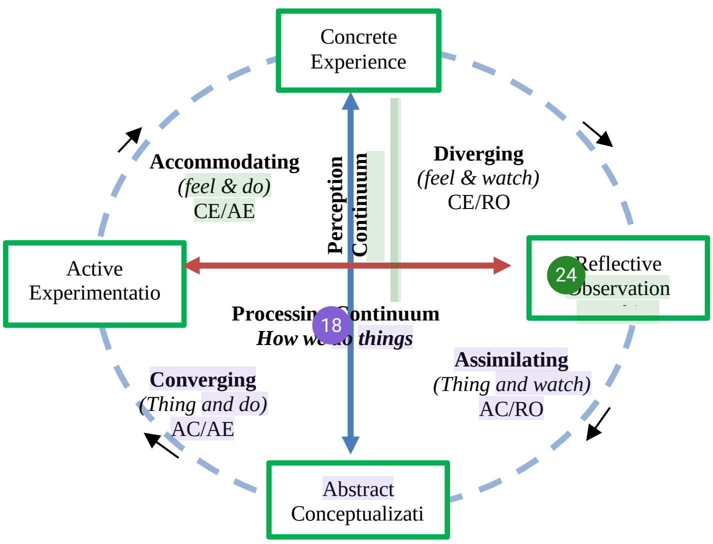

Figure 1. Kolb Learning Style

Based on the figure above, D. A. Kolb (1984) classifies a person's learning style into four categories that will be outlined as follows:

1. Diverger (feeling and watching)

   Divergent learning styles have the opposite learning power of the converge. It emphasizes real experience and reflective observation. Its greatest strength lies in imaginative abilities and awareness of meaning and values. Individuals with this learning style like learning tasks that require them to generate ideas, like cultural issues, and collect information. The approach to every situation is to observe and not act. Superior in looking at concrete situations from many different points of view.
2. Assimilator (watching and thinking)

   The assimilator learning style is a learning ability dominated by learning experiences through reflective observation and abstract conceptualization. Individuals with this learning style can understand various information presentations and summarize them logically, concisely and clearly. The greatest strength of this orientation lies in inductive reasoning and the ability to create theoretical models in assimilating different observations into integrated explanations. Usually, this individual has the nature of being less attentive to others and prefers ideas and concepts that are abstract and tend to be more theoretical.
3. Converges (thinking and doing)

   The converges learning style relies primarily on the dominant learning ability of abstract conceptualization and active experimentation. The greatest strength of this approach lies in problem-solving, decision-making, and practical application of ideas. The style works best in situations with one correct answer or solution to a question or problem. Individuals with this learning style prefer technical (applicative) tasks rather than social problems or interpersonal relationships in learning. They like experimental learning activities, demonstrations, simulations and practicums.
4. Accommodator (doing and feeling)

   Accommodating learning styles have the opposite power of assimilation, emphasizing real experience and active experimentation. The greatest strength of this orientation lies in doing things, carrying out plans and tasks and engaging in new experiences. Individuals with this learning style tend to act based on intuition/ impulse rather than based on logical analysis, considering the opinions/input of others more than technical analysts to solve problems. In addition, it also likes to make plans involving various new experiences and likes to be challenging.

Methods

This research uses a qualitative approach with a grounded theory method. Selection of grounded theory methods to obtain an overview of the visual thinking level of junior high school students with the learning style of assimilators, accommodators, converges and diverger in solving geometry problems. Through data collection and identification of visual thinking level indicators, researchers obtained a theoretical formulation to identify the achievement of students' levels and visual thinking characteristics in solving geometric problems. This is grounded theory, a systematic qualitative procedure used to produce a theory that explains, at the broad conceptual level, a process, action or interaction on a substantive topic (Cohen et al., 2007; Creswell, 2015)

This study was conducted on 20 male and 36 female grade IX students. Of the 56 students, researchers grouped students into the categories of assimilators with SA codes, accommodators with SM codes, converges with SC codes and diverger with SD codes. Furthermore, the instruments used in this study are in the form of learning style inventory (LSI) instruments used to obtain student learning styles and geometry problem-solving test instruments (TPMG), which are used to obtain an overview of visual thinking levels. The data in this study were obtained through LSI tests, TPMG tests and interviews. The geometry problem in question is as follows:

"Assume the $PQRS$ is a plan figure a 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 presentation stage, and the conclusion drawing stage. These stages can be seen in the following figure 3.

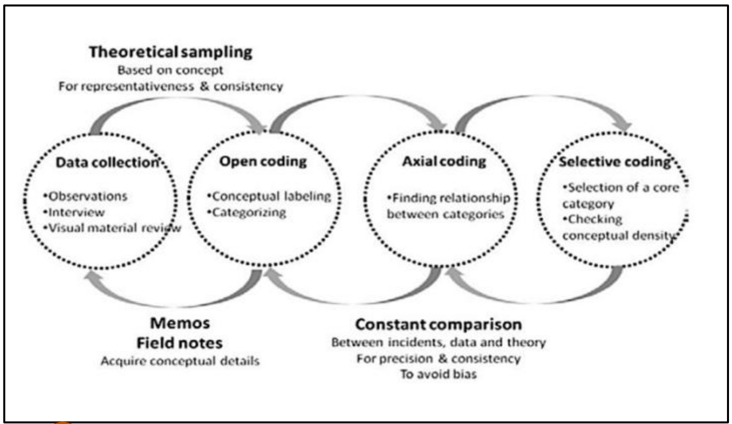

Figure 2. Data analysis procedure of grounded theory method

Results

The open coding stage is the stage in making code for students' answers and interview transcripts related to visual thinking in 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.

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

Based on the results of the analysis of TVTG 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:

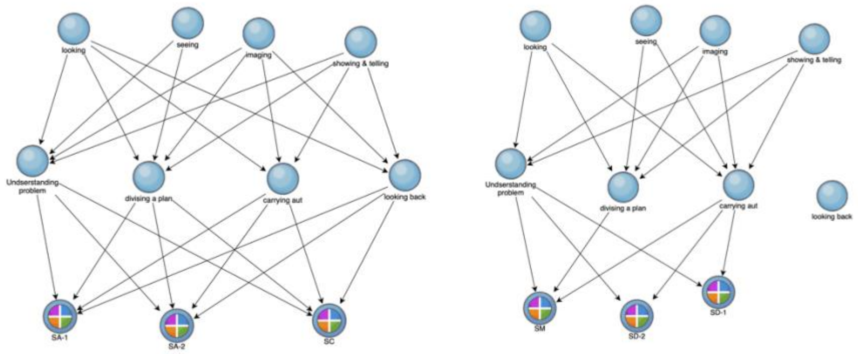

Figure 3. Visualization of student visual thinking activities

Based on the figure above, figure 3 shows the visual thinking activity of 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, and showing * 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 at the stage of understanding the problem and implementing 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:

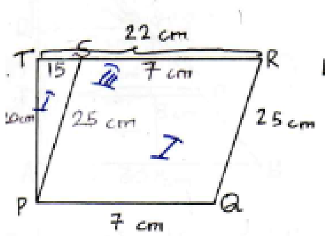

Figure 5. Illustration of the problem from SA-1

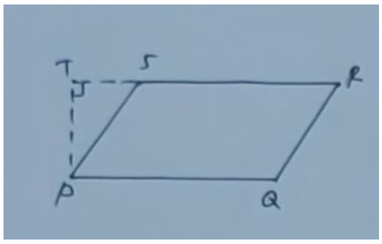

Figure 5. Illustration of the problem from SC

In Figure. 4 above, the SA-1, in illustrating the problem, can already understand the problem correctly and has a good understanding of the quadrilateral and the concept of two perpendicular lines well. Because SA-1 can already understand the problem well, illustrating images related to the problem is also appropriate. Likewise, the SC in illustrating the problem in the form of a picture is appropriate because the SC has also understood the problem correctly and has a good understanding of quadrilaterals and the concept of two perpendicular lines.

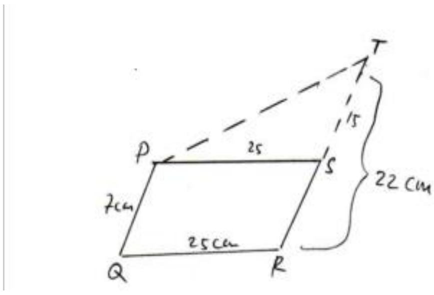

Figure 7. Illustration of the problem from SD-1

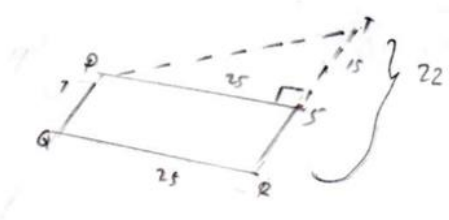

Figure 7. Illustration of the problem from SM

Unlike the SA-1 and SC, the figure above shows that SD-1 and SM in illustrating the problem in geometry images are incorrect. This is because SD-1 and SM have yet to understand the problem correctly and the concept of two perpendicular lines.

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

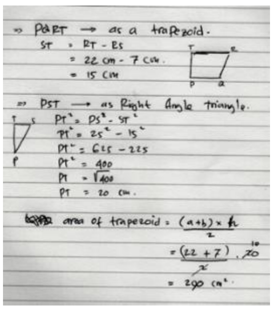

Figure 9. Solving geometry problems from SA-1

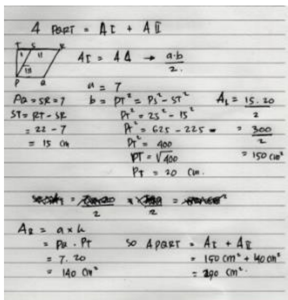

Figure 9. Solving geometry problems from SC

Figure 8. above shows that SA-1 can establish a problem-solving strategy appropriately. Then it can explain each concept to which the strategy is applied. So is SC, from Figure 8. the

above shows that the SC has established a strategy for obtaining the PQRT area. However, the strategy used by SC is different from the strategy implemented by SA-1. If SA-1 uses the trapezoid area formula while SC combines the area of the triangle PST and the area of the PQRS parallel. This shows that SA-1 and SC can already understand the concept of plane figure.

Figure 10. above shows that SD-1 set an improper strategy in solving the above problems.

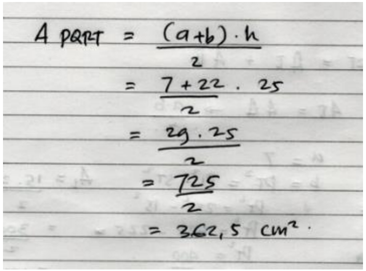

Figure 11. Solving geometry problems from SD-1

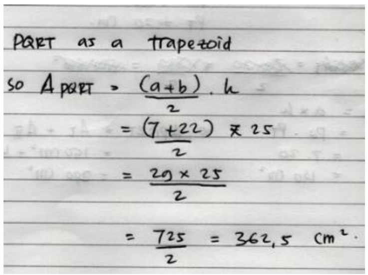

Figure 11. Solving geometry problems from SM

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.

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 to them. These other categories are causal conditions. An axial coding diagram is presented in the following figure:

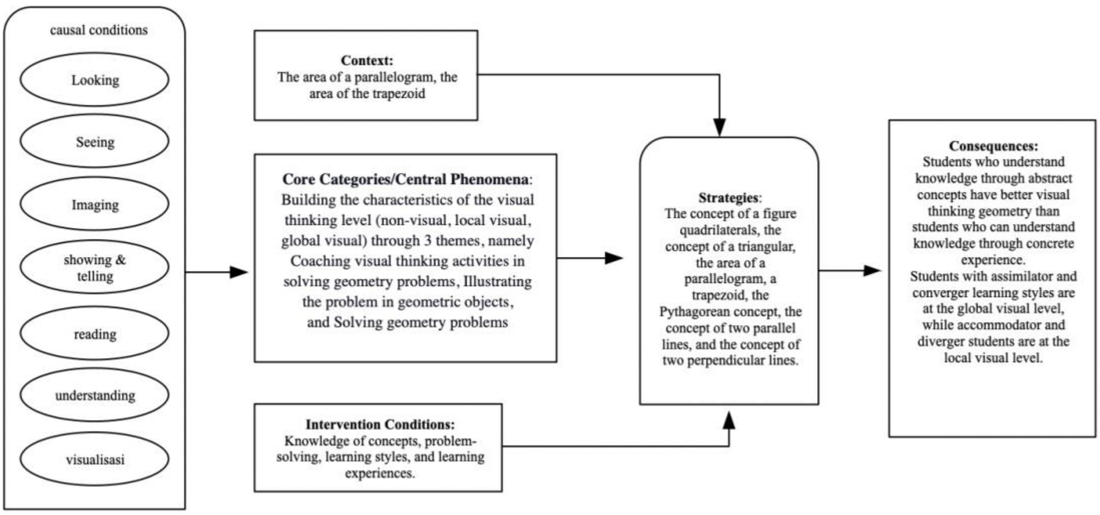

Figure 12. Solving geometry problems

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 is a process of integrating and refining 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 is 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 wide scope. However, neither is it hypothetical of minor work (Glaser & Strauss, 1967), but rather, the resulting theory is middle range (still talkable) (Charmaz, 2000).

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

Hypothetical conclusion 1: "students who can understand knowledge through abstract concepts have better visual thinking geometry than students who can understand knowledge through concrete experience."

Hypothetical conclusion 2: "students who have assimilator and converger learning styles are at the global visual level while accommodator and diverger students are at the local visual level".

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 recognizes 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 find solutions to 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 uses mathematical symbol representations in solving geometry problems, but at the stage of understanding the problem (grouping information based on known and questionable things) does 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 have 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, A. Y. Kolb & Kolb, (2005); D. A. 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. And also, in line with the results of the research of Wicaksono et al. (2021) that students who have an assimilator style can carry out the solution plan well and explain it logically. Then 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; U. 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 already 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 find solutions to 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 is only able to 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 (14-point, bold)

Based on the presentation of the results of this study, it can be concluded that the picture of the visual thinking level of assimilator and converges students in solving geometry problems is in level 2, namely Global Visual (GV). While the visual thinking level of accommodator and diverger students is at level 1, namely local visual (LV). Grounded theory analysis produces a theoretical conclusion: "students who can understand knowledge through abstract concepts have better visual thinking geometry compared to students who can understand knowledge through concrete experience." Students who can construct understanding through abstract concepts are assimilator and converges students, while students who can construct understanding through concrete experiences are accommodator and diverger students.

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Conflicts of Interest (13-point, bold)

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

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

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