

Geometry ability in Senior High School Students: Based on Learning Style

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DOI: 10.18326/hipotenusa.v6i1.1901

Article submitted: March 27, 2024

Article reviewed: May 13, 2024

Article published: June 27, 2024

Abstract

Geometry becomes an important component in mathematics which is learned by students at every stage. Learning style is one of the factors that influence students' geometry abilities. Therefore, it is important to describe how students' geometry abilities are viewed from learning styles. This research is quantitative descriptive research. The instruments used were a learning style questionnaire and a van hiele thinking test (VHGT). The data analysis technique used is descriptive statistical techniques with percentages, namely data from geometry tests that are successfully collected and then analyzed using a category assessment scale. The instruments used were the learning style questionnaire and the Van Hiele thinking test (VHGT). The research subjects were 276 high school students from eleven different schools in West Sumatra with the dominant learning style being visual as many as 104 students, followed by auditory as many as 98 and kinesthetic as many as 74. The results showed that the average students' geometric ability was 47.4 (on a scale of 0-100). In addition, students with a visual learning style have a higher average geometric ability compared to other learning styles. Therefore, it is hoped that teachers can consider using learning models that apply the Van Hiele level of thinking and the dominant learning style in geometry classes, for example by integrating technology.

Keywords: geometry ability, van hiele levels, learning styles

INTRODUCTION

The education system that is integrated into a curriculum cannot be separated from the learning process in the classroom. The interaction between teachers and students in transforming good knowledge will produce a golden generation as the nation's successor. Therefore, research in the field of education must continue to be carried out. Mathematics is an important component in education that is learned by students at every level of the educational unit.



The learning process in mathematics has long been the subject of study by many educational figures. Even though the curriculum continues to change, there are many aspects of mathematics that need to be analysed to be developed. This includes geometry which is a branch of mathematics. The role of geometry in everyday life makes it an important component that must be mastered by students. In general, students at every secondary school will study geometry as a sub-chapter in mathematics.

Geometry as a branch of mathematics is very close to students' daily lives. Students' mastery of geometry topics affects their ability to understand other mathematical topics (Meryansumayeka et al., 2022). The goal is that students can understand the properties and relationships between geometric elements and can become good problem solvers. However, in learning geometry it was found that students had difficulty in learning such as solving geometry problem (Fauzi & Arisetyawan, 2020) and the lack of student interest in learning mathematics (Novilanti & Suripah, 2021). The knowledge gained in class is not merely theoretical but can be applied in the real world (Firmanti et al., 2021). Students fail to understand key concepts in geometry and learn geometry without understanding basic terminology (Muslimin & Sunardi, 2019). This strongly suggests learning geometry that is in accordance with the level of students' thinking.

A person's geometry ability can be measured by doing the tests given. A student may experience conflict in solving geometry problems (Firmanti, 2022). In addition, interactions that occur among students who have various abilities provide an understanding of the opportunities to solve problems correctly (Utamingtyas et al., 2017). Furthermore, depending on each skill possessed. In fact, the geometry ability of high school students is still low. This is also reinforced by the results obtained from the Absorption Capacity of SMA or MA for the 2018/2019 school year in national percentages, which can be seen in Table 1 (Pusat Penilaian Pendidikan Kementerian Pendidikan dan Kebudayaan, 2019).

Table 1. The Percentage of Students Who Answered Correctly for the 2018/2019 Academic Year

No	Material tested	National
1	Algebra	38,50
2	Geometry and Trigonometry	36,54
3	Statistics	36,63

Resource: <https://hasilun.puspendik.kemdikbud.go.id>

The percentages from the table above can be seen for the three materials tested, it turns out that geometry and trigonometry material have the lowest percentage. In the geometry and trigonometry material tested, the percentage of students who answered correctly was 36.54%. From the above results it can be concluded that the difficulty level of learning geometry is quite high, so that students have difficulty solving problems.

Basically, a student's geometry ability can be measured through Van Hiele's level of thinking. This theory provides five levels of thinking in geometry sequentially, namely visualization, analysis, informal deduction, deduction and rigor. The visualization level or level 1 is called the recognition stage. At this stage students can model the information provided by the problem into geometric shapes. Analysis level (2), at this stage students are able to understand the properties of geometric shapes through informal analysis of

these shapes. In other words, students systematically arrange the data needed to solve the problem.

Informal deduction level (3), students are able to understand the sequence of geometric shapes or the relationship between shapes. For example, students can determine the shortest distance between a point and a line. At the deduction stage (4) students begin to be able to define elements that cannot be defined, theorems, axioms and definitions. Students are also able to compare the components of mathematical statements into geometric statements. At the last level, namely rigor (5), students can understand the importance of accuracy from the most basic things and use theory and postulates in understanding geometric concepts. Students' geometry abilities can be described based on these five levels.

In addition, Wulandari, et al (2022) also concluded that the characteristics of high school students were categorized into low, medium and high van hiele thinking levels. For more details can be seen in Table 2 (Wulandari & Ishartono, 2022):

Table 2. Grouping students' geometric thinking levels

No	Van Hiele Thinking Level Category	Achievement of van hiele level				
		Level 1	Level 2	Level 3	Level 4	Level 5
1	High level	√	√	√	-	-
2	Medium level	√	√	-	-	-
3	Low level	√	-	-	-	-

Information:

(√) already fulfilled

(-) not fulfilled

In general, junior high school students are still at the level of analysis (Yuliana & Ratu, 2019) and only a few reach the informal deduction stage or level 3 (Anwar, 2020) (Anwar, 2019). As for learning improvements can also be made so that students who were at the level of visualization can increase to informal deduction (Aziiza et al., 2022). High school students are also at the highest level of informal deduction (Wulandari & Ishartono, 2022). In addition, students at the rigor level have geometric skills in the form of visual, verbal and logic and students at the deductive level have visual and drawing skills (Afifah et al., 2019).

Learning geometry cannot be separated from one's spatial ability because one of the important components in geometric ability is spatial ability. Meanwhile, one that affects a person's spatial ability is learning style (Alfaruqi & Lutfianto, 2016). In other words, learning styles will affect students' geometry abilities. This is also in line with research conducted by Bosman, et al also stated that student learning styles are related to student performance in mathematics (Bosman & Schulze, 2018). Wicaksono also suggested differences in geometry problem solving abilities based on learning styles (Wicaksono et al., 2021). Learning styles determine student academic performance (Chetty et al., 2019). Moreover, the learning process is influenced by learning styles (Rini et al., 2020).

There are three learning styles that a student can have, namely visual, auditory and kinesthetic (Zagoto et al., 2019). Students with a visual learning style focus more on the sense of sight. Images, colors, and spatial relations, in this type of learning style, are more

prominent. Visual learners are avid readers; often gives short answers; prefer to read rather than be read to; prefers to do presentations/performances rather than just giving lectures; and prefer art.

Students with an auditory learning style focus on hearing in remembering something to absorb information. In other words, students must listen, only then can they understand/remember the knowledge acquired. All kinds of sounds and words are managed by this learning style. Meanwhile, the learning style with the kinesthetic type requires students to hold something that conveys certain data so that it can be remembered. They learn by moving, doing, or touching and can't stay still.

Some studies had been done by several researchers related to geometry and learning styles. During the learning activities, Gardner then describes nine different intelligences based on the aforementioned criteria; logical-mathematic (number smart), verbal-linguistic (word smart), bodily-kinesthetic (body smart), musical-rhythmic (music smart), interpersonal (people smart), visual-spatial (picture smart), intrapersonal (self-smart), naturalist (nature smart), existential. These intelligences are then related to students' learning styles, which are unique to each individual student (Şener & Çokçalışkan, 2018). The relationship of this can be shown in Figure 1 below.



Figure 1. Learning Styles and Multiple Intelligence

From figure 1 above it can be seen that those intelligences have different learning styles which is in line with visual-spatial. Actually, The relationship between geometry achievement and learning style is complex and can vary between individuals.(Zales & Vasquez, 2022) In general, each visual auditory and kinesthetic student has the ability to analyze, evaluate, and create as part of the higher order thinking component. However, each of them has a weakness in these abilities (Ishartono et al., 2021).

In geometry there are elements of the use of visualization, spatial reasoning and modeling. This shows that spatial ability is a curriculum demand that must be accommodated in learning geometry (Perangin-angin & Khayroiayah, 2021). One of the factors that influence spatial ability is learning style. In other words, learning styles will affect students' geometry abilities.

Therefore, researchers are interested in examining how high school students' geometry abilities are viewed from learning styles. This study aims to describe how the

geometric thinking skills of high school students as well as compare the geometric abilities of the three types of students with different learning styles.

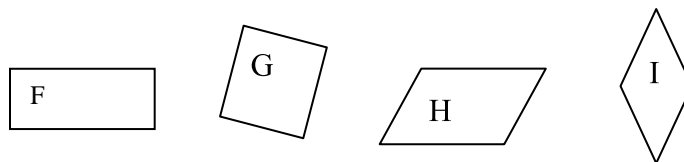
METHODS

The type of research conducted by the researcher is a type of qualitative descriptive research, because in addition to the researcher's role as the main instrument in this research process, the researcher also interacts and interacts directly with both the research subject, the situation and the symptoms being studied. The subjects in this study were 276 junior high school students from eleven different high schools in Bukittinggi, Agam and Payakumbuh (West Sumatra). Schools were randomly selected with different accreditations and one class was selected for each school. In general, the class chosen is class XII with the Science major.

The instruments in this study were a learning style questionnaire and a van hiele thinking test (VHGT). The questionnaire given is to determine student learning styles. While the test is given to measure the students' geometry abilities at which level. Each correct answer gets a score of 1 and an incorrect answer gets a score of 0. Next, each score is converted into a percentage with the highest score being 100 and the lowest score being 0. Moreover, this problem consists of 20 objective questions that measure the five levels of van Hiele geometry. Each level consists of four questions.

The questions at the first level discuss classifying quadrilaterals that belong to squares, triangles, trapezoids. For more details, see one of the examples below:

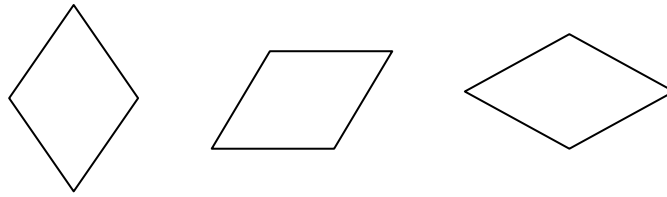
Which of the following figure is a square?



The optional answer for the question are: There is no square (A), Shape G (B), Shapes F and G (C), Shapes G and I (D), All shapes are square (E). The correct answer is B. At this stage students can understand the information contained in the problem and illustrate it in geometric shapes. The indicator is that students are asked to be able to illustrate and model the information contained in the problem into geometric shapes.

The questions at the second level discuss the characteristics of a plane shape and the relationship between the properties of that shape. For more details, see one of the examples below:

A rhombus is a shape with 4 sides that are the same length.



Which of the points (A)-(D) is not always true on the rhombus?

The optional answer for the question are: The two diagonals have the same length (A), Each diagonal divides two corners of rhombus (B), The two diagonals are perpendicular (C), The opposite angles have the same size (D), All points (a)-(d) is true in every rhombus (E). The correct answer is A. A rhombus has two diagonals that are perpendicular and all four sides are congruent. However, the diagonals of a rhombus are not congruent with each other. In other words, it means that there is a long diagonal and a short diagonal in a rhombus. At this stage students analyze the information contained in the problem to become the basis for a problem solving strategy. The indicator is that students can organize the data (information) needed to solve the problem.

The questions at the third level stated that students were able to see the relationship between the properties of a geometric shape and the properties between several geometric shapes. For more details, see one of the examples below:

There are two statements as follows.

Statement S: ΔABC has 3 sides with the same length

Statement T: ΔABC , $\angle B$ and $\angle C$ have the same measurement.

Which of the following statements are true?

The optional answer for the question are: Statements S and T are both incorrect (A), If S is true, then T is true (B), If T is true, then S is true (C), If S is false, then T is false (D), Neither of points (A)-(D) is correct (E). The correct answer is B. If three sides of a triangle are the same length, then the triangle is an equilateral triangle. Automatically, all of three angles in a triangle are also equal.

Questions at the fourth level ask students to be able to compile evidence, not just accept evidence. For more details, see one of the examples below:

These are 3 properties of certain figures

Property D: has diagonals that are the same length

Property S: is a square

Property R: is a rectangle.

Which of following are true?

The optional answer for the question are: If R and D so that S (A), If S and D so that R (B), If D and S so that R (C), If S and R so that D (D), If D and R so that S (E). The correct answer is C. At this stage students can compare the components of mathematical statements into geometric statements. The indicator is that students are able to understand concepts or theories related to geometric objects displayed in the geometric illustrations in the questions.

Questions at the fifth level ask students to reason formally in mathematical systems and to be able to analyze the consequences of manipulating axioms and definitions. For more details, see one of the examples below:

To trisect an angle means to divide into three equal parts. In 1847, P.L. Wantzel proved that, in geometry, it is not possible to trisect angles using only a compass and an unmarked ruler. From the evidence, what can you conclude?

The optional answer for the question are: In general, it is not possible to bisect angles using only a compass and an unmarked ruler (A), In general, it is not possible to trisect angles using only a compass and a marked line (B), In general, it is not possible to trisect angles using some drawing tools (C), It is still possible that in the future someone might find a general way to bisect angles using only a compass and an unmarked ruler (D), No one has ever been able to devise a general method for bisecting angles using only a compass and an unmarked ruler (E). The correct answer is E. At this stage students use theory and postulates in understanding geometric concepts. Students can use geometric theory and postulates to draw conclusions.

Furthermore, the data analysis technique used is descriptive statistical techniques with percentages, namely data from geometry tests that are successfully collected and then analyzed using a category assessment scale.

RESULTS AND DISCUSSION

Result

Questionnaires were given to 276 high school students as research subjects to group students based on learning styles. They are 104 students with visual learning style, 98 students with auditory learning style and 74 students with kinesthetic learning style. This shows that the visual learning style is still dominantly owned by students. In detail, the distribution of student learning styles can be seen in the table below:

Table 3. Distribution of Student Learning Styles

No	Gaya belajar dominan	The number of students	Percentage (%)
1	Visual	104	38
2	Auditory	98	35
3	Kinesthetic	74	27
	Total	276	100

After the questionnaire was given, the research subjects were then given a van hiele thinking test (VHGT). This question relates to the three dimensional material being studied in class XII. The level of geometric ability can be seen through the description below:

Geometry ability of visual learning style students

Of the 276 questionnaires distributed, it can be concluded that around 38% of high school students' learning style is visual. This shows that most students in one class have a visual learning style. For more details can be seen in the table below:

Table 4. Students' Geometry Abilities for Visual Learning Styles

No	Van Hiele Levels	Converted Score	Number of Students
1	5	100	16
2	4	80	10
3	3	60	24
4	2	40	42
5	1	20	12
Total number of students			104
Mean			55,38

Based on Table 1 above, it can be seen that the average geometry ability of students with a visual learning style is at a score of 55.38. There are 26 students who have fulfilled the geometric thinking level for high school level or around 25% from students who have a visual learning style.

Geometry ability of auditory learning style students

Of the 276 questionnaires distributed, it can be concluded that around 35% of high school students' learning styles are auditory. For more details, see the table below

Table 5. Students' Geometry Abilities for Auditory Learning Styles

No	Van Hiele Levels	Converted Score	Number of Students
1	5	100	7
2	4	80	4
3	3	60	21
4	2	40	43
5	1	20	23
Total number of students			98
Mean			45,51

Based on Table 2 above, it can be seen that the average geometry ability of students with an auditory learning style is at a score of 45.51. There are 11 students who have fulfilled the level of geometric thinking for the high school level or about 11%.

Geometry ability of kinesthetic learning style students

Of the 276 questionnaires distributed, it can be concluded that around 26% of high school students' learning style is visual. For more details, see the table 6.

Table 6. Students' Geometry Abilities for Kynesthetic Learning Styles

No	Van Hiele Levels	Converted Score	Number of Students
1	5	100	2
2	4	80	3
3	3	60	10
4	2	40	32
5	1	20	27
Total number of students			74
Mean			38,65

Based on Table 3 above, it can be seen that the average geometry ability of students with a visual learning style is at a score of 38.65. There are 5 students who have fulfilled the level of geometric thinking for the high school level or around 6.8%.

Discussion

Based on the description of the results of the study above, it shows that students at level 5. 16 come from students with a visual learning style, 7 from students with an auditory learning style and 2 from students with a kinesthetic learning style. This shows that students with a visual learning style dominate at level 5. On the other hand, at the lowest level (level 1) 12 people come from a visual learning style, 23 come from an auditory learning style and 26 come from students with a kinesthetic learning style. For more details, see the diagram below:

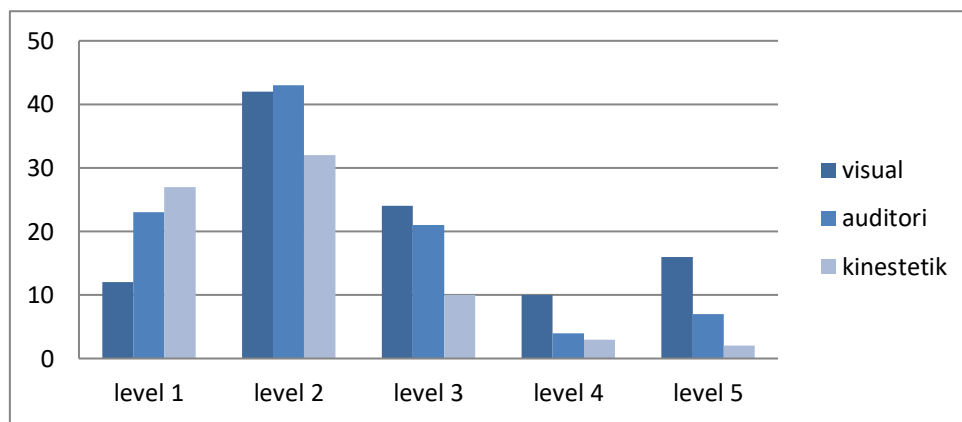


Figure 2. Students' geometric abilities based on level Van Hiele

Based on the diagram above, the geometry abilities of high school students are dominantly at level 2 (analysis). This shows that learning improvements especially in geometry need to be done. One strategy that can be implemented is by integrating mathematics learning with technology such as using GeoGebra software. This is in accordance with research conducted by Rohaeti and Benard (2018) that students' achievement and improvement in mathematical understanding skills are better using Geogebra (Rohaeti & Bernard, 2018).

Based on the result, the percentage of students with the high van hiele thinking levell category is 35.1%, the medium category is 42.4% and the low is 22.5%. In addition, the percentage for geometry abilities of high school students who had just reached levels 4 and 5 was 42 people out of 276 research subjects or around 15.21%. The highest level of high school students comes to informal deduction (Wulandari & Ishartono, 2022). Therefore, it is necessary to improve learning that must be done. One of them is by applying a learning model that considers the stages at the Van Hiele geometric thinking level. This is because there have been many studies conducted that the application of the model has a positive influence on students' geometry abilities (Yudianto et al., 2022). Moreover, the average of geometry ability's student from learning style can be seen from the Figure 3.

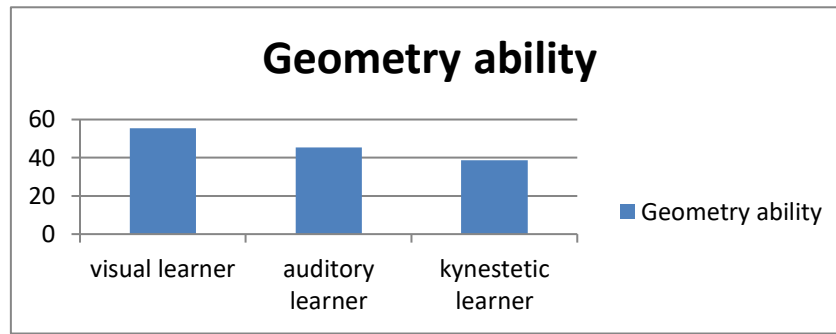


Figure 3. Students’ geometric abilities based on learning style

Based on the Figure 3, the geometric ability score of students with a visual learning style is 55.38 (the highest score), students with an auditory learning style are 45.51 and students with a kinesthetic learning style are 38.65. Students with a visual learning style are good at seeing relationships between spaces. Research conducted by Setyawati (2018) states that there is a significant stylistic influence between visual learning styles and geometry learning outcomes of 62.8% (Setyawati, 2018). In addition, visual students also fulfill the three indicators of creative thinking compared to auditory learning style students in solving geometry problems (Jagom. Yohanes Ovaritus, 2015). Students with a visual learning style understand problems systematically and clearly in determining what is known and unknown from the data provided (Machromah et al., 2021).

Based on the description above, the average student geometry ability after conversion is 47.4. Therefore, the application of a learning model that is adapted to the level of students' geometric thinking has an influence on student achievement in the classroom. For example, three-dimensional material related to the problem instrument, previously had experienced a shift in being taught in class X. But now it is being studied in class XII. The teacher gave a positive response to this shift in order. This is because there are difficulties in discussing questions involving sine and cosine rules that have not been studied. So, three-dimensional material is suitable for learning in students in class XII.

CONCLUSION

Based on the description above, it can be concluded that the dominant learning style possessed by students in a class is visual. In addition, the geometry ability of high school students as a whole is 47.4. Moreover, the percentage of students with the high van hiele thinking level category is 35.1%, the medium category is 42.4% and the low is 22.5%. This shows that students' geometry abilities are still at a lower level.

Moreover, the geometry abilities of students who have visual learning style is the highest compared to auditory and kinesthetic. One of the factors that influence the ability of geometry is the learning style of students. Therefore, it is hoped that teachers will consider using a learning model that applies the van Hiele level of thinking and the dominant learning style in the geometry class.

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