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The Influence of Visual Learning Style and Mathematical Learning Motivation on Geometry Understanding of Class X Students of MAN 2 Palu City

Achmad Nuuryadin*, Rafiq Badjeber, Yulia
Tadris Matematika, FTIK UIN Datokarama Palu, Palu, 94221, Indonesia

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** Corresponding author:*

E-mail: ydnnachmd05@gmail.com

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A B S T R A C T

This study aims to analyze the influence of visual learning styles and mathematical learning motivation on the understanding of geometry material of class X students of MAN 2 Palu City. This study is motivated by the importance of visualization abilities and learning motivation in understanding abstract and spatial geometric concepts. The study uses a quantitative approach with an ex post facto research type. The research sample consisted of 219 students selected using a simple random sampling technique. Data collection was carried out through a visual learning style questionnaire, a mathematical learning motivation questionnaire, and a geometry understanding test. Data analysis used multiple linear regression. The results showed that visual learning styles had a positive and significant effect on geometry understanding with a significance value of 0.001. Mathematical learning motivation also had a positive and significant effect with a significance value of 0.001. Simultaneously, both variables had a significant effect on geometry understanding with an F_count value of 163.484 and a coefficient of determination of 0.602. This study concluded that students' geometry understanding was influenced by their visual abilities and mathematical learning motivation.

1. Introduction

Mathematics is a subject that has an important role in the world of education (Husnul Fauzan & Khairul Anshari, 2024). In various education systems around the world, mathematics is an integral part of the curriculum because it is closely related to logical thinking skills, problem solving, and quantitative analysis (Siswanto & Meiliasari, 2024). As a fundamental subject, mathematics is not only taught as a separate discipline but is also used in various fields such as science, technology, and economics. A good understanding of mathematical concepts is a primary requirement for students to develop in other disciplines (Radiusman, 2020).

However, even though mathematics has a very important role, many students have difficulty in understanding mathematical concepts, especially in geometry material (Hanan & Alim, 2023). This difficulty is a major concern in education because a good understanding of geometric concepts will impact the development of students' spatial and analytical thinking skills. Therefore, it is important to examine factors that can help improve students' understanding of geometry, such as learning styles and motivation (Buyung et al., 2022). Learning motivation is considered an important factor that influences students' participation, persistence, and achievement in mathematics learning (Novitasari & Fathoni, 2026; Juraidah et al., 2025).

One area of mathematics that often presents challenges for students is geometry. Geometry is a branch of mathematics that deals with the shape, size, relative position of objects, and the properties of space (Hanan & Alim, 2023). Many students have difficulty understanding geometric concepts because they require good visualization skills (Umland & Sriraman, 2020). Additionally, in geometry learning, students are required to understand the relationships between shapes and use logic to solve problems. Difficulties in understanding geometry are often caused by a lack of visualization skills and low student motivation (Hanan & Alim, 2023). Various studies show that many students experience difficulties in understanding basic geometric concepts, such as plane figures, spatial figures, angles, and the relationships between geometric shapes (Milkhaturrohman et al., 2022). This difficulty is not only caused by a lack of skills in visualizing geometric shapes, but also by a lack of application of learning methods that are appropriate to student characteristics (Amaliyah et al., 2022).

One factor thought to influence students' understanding of geometry material is learning style. In the VARK model developed by Fleming and Mills, students with a tendency toward visual learning styles tend to more easily understand information presented in the form of diagrams, graphs, symbols, and other visual representations (Fleming & Mills, 1992). Learning style refers to the way an individual acquires, processes, and stores information. (Ema Lestari et al., 2023). In the context of geometry learning, students with a visual learning style can better understand geometric concepts if they are given clear illustrations and the use of learning media that supports visualization (Afiqa et al., 2024). A research shows that visualization and visual representation abilities contribute to students' understanding of geometric concepts (Fujita et al., 2020). In geometry learning, visual representations help students establish spatial relationships, recognize patterns, and abstract formal mathematical objects. These findings indicate that visual learning style characteristics have the potential to support optimal understanding of geometric concepts. In addition to learning style, learning motivation also plays a crucial role in student success in understanding geometry (Kurniawan et al., 2024). Previous studies published in the Journal of Educational Sciences also reported that learning styles contribute to students' motivation, engagement, and mathematical understanding (Jonivan et al., 2026; Nurhidayah et al., 2026).

Students with high learning motivation tend to be more persistent in understanding mathematical concepts and seek out various ways to improve their understanding.

Conversely, students with low motivation tend to be passive in learning, put less effort into solving problems, and give up more quickly when faced with difficulties in understanding geometry material (Mirna et al., 2023). Research by (Sinaga, 2022) shows that students with high motivation to learn mathematics tend to have better cognitive engagement and problem-solving abilities than students with low learning motivation. Learning motivation encourages students to be more active in exploring problem-solving strategies, maintaining effort when facing difficulties, and increasing perseverance in understanding mathematical concepts.

From the various factors discussed, visual learning styles and learning motivation have a significant influence on students' understanding of geometry. Students who possess a dominant visual learning style coupled with high learning motivation tend to grasp geometric concepts more easily and are more capable of solving problems related to shape, size, and space. Conversely, students with a visual learning style who lack motivation may not be able to fully utilize the advantages of their learning style (Effendi et al., 2023). In addition, interactive and visual learning media were found to positively support students' learning motivation and conceptual understanding in classroom learning (Asriani et al., 2026).

Various previous studies have examined the relationship between learning styles and learning motivation toward students' mathematics learning outcomes. A previous study found that learning styles influence mathematics learning outcomes, where students with a visual learning style achieved better results compared to those with an auditory learning style in certain instructional contexts. The study employed a quasi-experimental approach with a 2×2 factorial design to examine the interaction between learning models and learning styles on mathematics learning outcomes (Sembiring & Situmorang, 2015). Another study conducted found that learning styles and learning motivation simultaneously had a positive influence on elementary school students' mathematics learning outcomes. The study employed a quantitative correlational approach using two-way ANOVA analysis. The findings revealed that learning motivation contributed more significantly than learning styles to students' mathematics learning outcomes (Widiyani et al., 2020).

Furthermore, a previous study examined the influence of learning styles, learning motivation, mathematics anxiety, and attitudes on elementary school students' mathematics learning outcomes. The ex post facto study revealed that learning styles and learning motivation contributed to students' achievement in mathematics learning outcomes (Nurawaliah et al., 2023). Furthermore, another study found a positive relationship between learning styles and mathematics learning motivation toward students' mathematics achievement. The study employed a quantitative correlational method using a cluster random sampling technique and revealed that both variables jointly contributed to students' mathematics achievement (Chasanah et al., 2019).

Nevertheless, although previous studies have examined the influence of learning styles and learning motivation on mathematics learning outcomes, most studies still focus on mathematics achievement in general and have not specifically investigated understanding of geometry as a form of students' mathematical conceptual ability.

In addition, most previous research was conducted at the elementary school level, while studies involving Madrasah Aliyah students remain limited. Previous studies also tended to position learning outcomes as the final achievement of instruction rather than focusing on geometric understanding related to students' visualization and spatial representation abilities. Therefore, this study attempts to fill this gap by examining the influence of visual learning styles and mathematical learning motivation on the geometry understanding of tenth-grade Madrasah Aliyah students through an ex post facto approach. The relationship between these two variables and students' understanding of geometry is important to investigate because it may provide insights into how effective instructional strategies can be implemented in the classroom. By understanding the role of learning styles and motivation in geometry learning, educators can design teaching methods that are more effective and aligned with students' characteristics.

This study aims to analyze the influence of visual learning styles and mathematical learning motivation on the geometry understanding of tenth-grade students at MAN 2 Palu City. Specifically, this study seeks to determine: (1) the influence of visual learning styles on students' geometry understanding, (2) the influence of mathematical learning motivation on students' geometry understanding, and (3) the simultaneous influence of visual learning styles and mathematical learning motivation on students' geometry understanding. The findings of this study are expected to provide empirical contributions to the development of more effective mathematics learning strategies, particularly in geometry instruction that accommodates students' learning characteristics and motivational aspects.

2. Methodology

In this study, a quantitative approach was employed using an ex post facto research design. The study investigated the influence of visual learning styles and mathematics learning motivation on students' understanding of geometry among tenth-grade students at MAN 2 Palu City. MAN 2 Palu City was selected as the research location because the school had implemented geometry learning at the tenth-grade level and represented students with diverse academic characteristics relevant to the objectives of this study. A total of 219 students were selected as the research sample using a simple random sampling technique to select the research participants. Based on this explanation, the research design was intended to clarify and demonstrate the relationship among the variables studied.

Data Collection

The data collection techniques used in this study were questionnaires and written tests. Questionnaires were used to measure students' levels of visual learning styles and mathematical learning motivation. Prior to their implementation, the visual learning style and mathematical learning motivation questionnaires were tested for validity and reliability on 100 students. Validity testing was conducted using the Pearson Product Moment correlation between item scores and total scores with the assistance of SPSS software. The results indicated that all items in both instruments

were valid, as the item-total correlation coefficients were greater than the $r_{table} = 0{,}196$ at the 5% significance level.

Instrument

In the visual learning style instrument consisting of 17 items, the item-total correlation coefficients ranged from 0.274 to 0.768. Meanwhile, in the mathematical learning motivation instrument consisting of 15 items, the item-total correlation coefficients ranged from 0.418 to 0.688. All items showed significance values of $p < 0{,}05$, indicating that they met the criteria for empirical validity. Furthermore, reliability testing was conducted using Cronbach's Alpha coefficients. The results showed that the visual learning style instrument obtained a Cronbach's Alpha value of 0.747, while the mathematical learning motivation instrument obtained a value of 0.832. Based on the reliability criteria, both instruments were categorized as reliable and therefore considered appropriate for use as research instruments. The reliability test results for variables X1 and X2 are presented in Table 1.

Table 1. Reliability Test of Variable X1 and X2

Cronbach's Alpha	N of Items	
X1	.747	17
X2	.832	15

To measure students' understanding of the material, a test instrument was employed in this study. The material understanding test instrument consisted of five essay questions developed based on the indicators of conceptual understanding. Prior to its implementation on the research sample, the test instrument was validated by two expert validators in the field of mathematics education. The validation process was conducted through expert judgment by assessing several aspects, including the suitability of the test with basic competencies, the appropriateness of the test indicators, the criteria of material understanding, the clarity of the test instructions, and the level of difficulty of the questions using a 1–4 rating scale. The content validity results were analyzed using Aiken's V index. Based on the analysis, the content validity values for each test item ranged from 0.90 to 1.00. These results indicate that all test items possessed very high content validity and were therefore appropriate for use as research instruments.

Data Analysis

The data analysis techniques used in this study included descriptive statistics, classical assumption tests, and multiple linear regression analysis to determine the relationships among the variables. Descriptive statistics were used to describe the distribution of each variable, while classical assumption tests were conducted to ensure that the data met the requirements for regression analysis. Furthermore, multiple linear regression analysis was applied to examine the influence of visual learning style and learning motivation on students' understanding of geometry. The operationalization of each variable was based on the indicators presented in Table 3, Table 4, and Table 5. These indicators served as the foundation for constructing

research instruments, defining measurement dimensions, and interpreting the results of the study.

Table 3. Indicators of Visual Learning Style

No.	Indicators
1	Neat and organized
2	Careful and thorough
3	Good long-term planner and organizer
4	Remembers through visual association
5	Easier to remember what is seen than what is heard
6	Has difficulty remembering verbal instructions

Source: (Setiana & Purwoko, 2020)

Table 4. Indicators of Learning Motivation

No.	Indicators
1	Intrinsic motivation
2	Extrinsic motivation
3	Task value
4	Belief
5	Self-efficacy

Source: (Khoirunnisa & Ulfah, 2021)

Table 5. Indicators of Material Understanding

No.	Indicators
1	Restating concepts that have been learned
2	Classifying objects based on whether they fulfill the requirements for forming a concept
3	Presenting concepts in various forms of mathematical representation
4	Providing examples and non-examples in various forms of mathematical representation
5	Relating concepts to other concepts

Source: (Nastiti & Syaifudin, 2020)

3. Results and Discussion

The results and discussion section presents the findings of the statistical analyses conducted to examine the influence of visual learning styles and mathematical learning motivation on students' understanding of geometry material among tenth-grade students at MAN 2 Palu City. Prior to hypothesis testing, descriptive statistical analysis and classical assumption tests were carried out to ensure that the research data met the requirements for multiple linear regression analysis. The analyses included descriptive statistics, normality tests, multicollinearity tests, heteroscedasticity tests, multiple linear regression analysis, partial tests, simultaneous tests, and coefficient of determination analysis.

This study was conducted systematically beginning with the distribution of visual learning style and mathematical learning motivation questionnaires to the selected research participants. Furthermore, students were given a geometry material understanding test consisting of essay questions designed to measure conceptual understanding and students' abilities in identifying, representing, and relating geometric concepts. The collected data were then analyzed quantitatively to determine the relationships and influences among the research variables. The results of these analyses are expected to provide empirical evidence regarding the importance of cognitive and affective factors in supporting students' understanding of geometry learning.

Descriptive statistical analysis was conducted to provide an overview of the characteristics and distribution of the research data related to visual learning styles, mathematical learning motivation, and students' understanding of geometry material. The descriptive analysis includes the minimum score, maximum score, mean, and standard deviation values for each research variable. The results of the descriptive statistical analysis are presented in Table 6.

Table 6. Descriptive Statistics

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Visual Learning Style	219	60	99	84.32	6.531
Mathematical Learning Motivation	219	63	100	84.79	7.412
Material Understanding	219	50	100	83.33	13.101
Valid N (listwise)	219				

Descriptive statistical analysis was conducted to provide a general overview of the data characteristics related to visual learning styles, mathematical learning motivation, and geometry material understanding among tenth-grade students at MAN 2 Palu City. The analysis results indicate that the visual learning style variable obtained a mean score of 84.32 with a standard deviation of 6.531. The mathematical learning motivation variable had a mean score of 84.79 with a standard deviation of 7.412. Meanwhile, the geometry material understanding variable obtained a mean score of 83.33 with a standard deviation of 13.101.

The mean scores of the three variables indicate that students tended to possess relatively high levels of visual learning styles, mathematical learning motivation, and geometry understanding. In addition, the relatively small standard deviation values indicate that the data distribution tended to be homogeneous, suggesting that the variation in responses among participants was not excessively extreme. Substantively, these findings indicate that students at MAN 2 Palu City demonstrate learning characteristics that are relatively adaptive to mathematics learning, particularly in geometry topics that require visual representation and spatial reasoning abilities.

Before conducting multiple linear regression analysis, classical assumption tests were first performed to ensure that the research data met the statistical requirements for regression analysis. One of the assumptions tested was the normality of the data

distribution. The normality test aims to determine whether the residual values in the regression model are normally distributed so that the regression analysis can produce unbiased and reliable estimates. The results of the normality test are presented in Table 7.

Table 7. Normality Test

One-Sample Kolmogorov-Smirnov Test		
		Unstandardized Residual
N		219
Normal Paramaters[a.b]	Mean	.0000000
	Std. Deviation	9.08132597
Most Extreme Differences	Absolute	.050
	Positive	.026
	Negative	-.050
Test Statistics		.050
Asymp. Sig. (2-tailed)°		$.200^{d}$

The normality test was conducted using the Kolmogorov–Smirnov test and produced a significance value of 0,200 ($p > 0{,}05$). These results indicate that the research data were normally distributed and therefore fulfilled the basic assumptions required for multiple linear regression analysis. A normal data distribution indicates that the regression model has relatively unbiased parameter estimates and is appropriate for hypothesis testing. After the normality assumption was fulfilled, the next classical assumption test conducted in this study was the multicollinearity test. This test was carried out to determine whether strong correlations existed among the independent variables, namely visual learning style and mathematical learning motivation. A good regression model should not contain multicollinearity because excessively high correlations among independent variables can affect the stability and accuracy of the regression coefficients. The multicollinearity test results are presented in Table 8.

Table 8. Multicollinearity Test

No	Variables	Tolerance	VIF
1	Visual Learning Style	.877	1.141
2	Mathematical Learning Motivation	.877	1.141

The multicollinearity test results indicate that the visual learning style and mathematical learning motivation variables obtained tolerance values of 0.877 and Variance Inflation Factor (VIF) values of 1.141. Tolerance values greater than 0.10 and VIF values lower than 10 indicate that no multicollinearity occurred among the independent variables. Thus, each independent variable contributed independently in explaining variations in students' geometry material understanding. After the multicollinearity assumption was fulfilled, a heteroscedasticity test was conducted to determine whether the residual variance in the regression model was homogeneous. A good regression model should not exhibit heteroscedasticity. The results of the heteroscedasticity test are presented in Table 9.

Table 9. Heteroscedasticity Test

Model	R	R Square	Adjusted R square	Std. Error of the Estimate
1	$.363^a$	.132	.112	95.78904

The heteroscedasticity test was conducted using the White test. Based on the analysis results, the R^2value was 0,132, resulting in the following χ^2_{count} value: $\chi^2 = n \times R^2 = 219 \times 0{,}132 = 28{,}908$. The obtained value was smaller than the χ^2_{table} value of 253.444. Therefore, the regression model did not experience heteroscedasticity. These findings indicate that the residual variance in the regression model was homogeneous, suggesting that the regression model was appropriate for hypothesis testing. The results of the classical assumption tests indicate that the research data fulfilled the requirements for regression analysis. Therefore, multiple linear regression analysis was conducted to determine the influence of visual learning styles and mathematical learning motivation on students' geometry material understanding. The results of the multiple linear regression analysis are presented in Table 10.

Table 10. Multiple Linear Regression Analysis

Coefficients

Model		Unstandardized Coefficients B	Sig.
1	(Constant)	148.276	0.001
	Visual Learning Style	1.237	0.001
	Mathematical Learning Motivation	0.464	0.001

The results of the multiple linear regression analysis produced the following regression equation: $Y = 148.276 + 1.237X_1 + 0.464X_2$.Description: Y= Geometry material understanding, X_1= Visual learning style, X_2= Mathematical learning motivation. The regression equation indicates that visual learning styles and mathematical learning motivation had a positive relationship with students' geometry material understanding. The regression coefficient for the visual learning style variable was 1.237, indicating that every one-unit increase in visual learning style would be followed by an increase of 1.237 units in geometry material understanding, assuming other variables remained constant.

Meanwhile, the regression coefficient for mathematical learning motivation was 0.464, indicating that an increase in mathematical learning motivation would be followed by an increase of 0.464 units in geometry understanding. To determine the partial influence of each independent variable on students' geometry material understanding, a partial significance test (t-test) was conducted. This analysis aimed to examine whether visual learning style and mathematical learning motivation individually had significant effects on the dependent variable. The results of the partial test are presented in Table 11.

Table 11. Partial Test (t-test)

Coefficients		
Model	**t**	**Sig.**
Visual Learning Style	8.070	.001
Mathematical Learning Motivation	5.732	.001

Dependent Variable: Material Understanding

The partial test results indicate that the visual learning style variable obtained a t_{count} value of 8.070 with a significance value of 0.001. Since the significance value was smaller than 0.05, visual learning style significantly influenced students' geometry material understanding. Meanwhile, the mathematical learning motivation variable obtained a t_{count} value of 5.732 with a significance value of 0.001. Since the significance value was lower than 0.05, mathematical learning motivation had a positive and significant influence on students' geometry material understanding. After examining the partial effects of each independent variable, a simultaneous test (F-test) was conducted to determine the combined influence of visual learning style and mathematical learning motivation on students' geometry material understanding. The results of the simultaneous test are presented in Table 12.

Table 12. Simultaneous Test (F-test)

ANOVA[a]					
Model	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	22531.817	2	11265.908	163.484	.001
Residual	14884.850	216	68.911		
Total	37416.667	218			

Dependent Variable: Material Understanding
Predictors: (Constant), Mathematical Learning Motivation, Visual Learning Style

The simultaneous test results showed a significance value of 0.001 with an F_{value} value of 163.484. The significance value, which was smaller than 0.05, indicates that visual learning style and mathematical learning motivation simultaneously had a significant influence on students' geometry material understanding. To determine the extent to which visual learning style and mathematical learning motivation contributed to students' geometry material understanding, a coefficient of determination analysis was conducted. The results of the coefficient of determination analysis are presented in Table 13.

Table 13. Coefficient of Determination

Model Summary[b]				
Model	**R**	**R Square**	**Adjust R Square**	**Std. Error of the Estimate**
1	.776[a]	.602	.599	8.301

Predictors: (Constant), Mathematical Learning Motivation, Visual Learning Style
Dependent Variable: Material Understanding

The analysis results showed a correlation coefficient (R)value of 0.776 and a coefficient of determination (R^2)value of 0.602. These results indicate that 60.2% of the variation in students' geometry material understanding could be explained

by visual learning styles and mathematical learning motivation. Meanwhile, the remaining 39.8% was influenced by other factors outside the research model, such as prior mathematical ability, instructional strategies, mathematics anxiety, and students' learning environments. The coefficient of determination indicates that the research model possessed relatively strong explanatory power in explaining the relationships among the research variables.

The findings of this study indicate that visual learning styles had a positive and significant influence on students' geometry material understanding. These findings suggest that visual representation plays an important role in helping students develop conceptual understanding of geometric objects that are abstract and spatial in nature. In the context of geometry learning, visualization serves not only as an illustrative medium but also as a cognitive instrument that enables students to construct spatial relationships, understand geometric structures, and abstract formal mathematical concepts. In Van Hiele's theory of geometric thinking development, the initial stage of geometric understanding is characterized by visualization skills, namely the ability of students to recognize the shape and characteristics of geometric objects based on visual representations before progressing to the stage of formal analysis and deduction (Hiele, 1986). Thus, visualization forms a crucial foundation for the development of students' geometric reasoning. The findings of this study are relevant to contemporary mathematics education studies, which place visualization as a fundamental component in the development of students' geometric reasoning. These findings are consistent with previous studies published in JES, which revealed that learning styles contribute to students' mathematical engagement and understanding in solving mathematical problems (Nurhidayah et al., 2026). Mathematical visualization skills are closely related to the development of students' spatial understanding and geometric reasoning (Joswick Candace et al., 2023).

Furthermore, Jerome Bruner's representation theory explains that understanding of mathematical concepts develops through the stages of enactive, iconic, and symbolic representation (Bruner, 1966). At the iconic stage, students understand concepts through images, diagrams, and visual representations before being able to understand mathematical symbols abstractly. In this context, visually inclined students tend to understand diagrams, patterns, shapes, and geometric relationships more easily because the information is presented in visual representations that are more closely aligned with their cognitive processes.

However, the results of this study cannot be interpreted as meaning that visual learning style is the sole factor that deterministically determines success in mathematics learning. In modern educational studies, the concept of learning styles remains a matter of academic debate because not all studies have demonstrated consistent empirical evidence regarding the effectiveness of adapting learning based on specific learning styles (Pashler et al., 2008). Therefore, visual learning style in this study is more accurately understood as a learning preference tendency that can support the process of geometric understanding, rather than as the sole determinant of student academic achievement.

The results also indicate that mathematical learning motivation has a positive and significant effect on students' understanding of geometry material. This finding indicates that students with high learning motivation tend to be more cognitively active, more persistent in solving mathematical problems, and have better learning persistence when facing difficulties in understanding geometric concepts. From an educational psychology perspective, learning motivation is an affective factor closely related to students' cognitive engagement. The Self-Determination Theory developed by Ryan & Deci explains that intrinsic motivation contributes to the quality of learning engagement, academic persistence, and learning achievement (Ryan & Deci, 2020).

In geometry learning, learning motivation plays a crucial role because geometry demands relatively complex abstraction, deductive reasoning, and visualization skills compared to other mathematical materials. Students with high learning motivation tend to be better able to maintain attention, explore problem-solving strategies, and develop deeper conceptual understanding. This finding is also supported by previous studies in JES indicating that learning motivation significantly affects students' participation and achievement in mathematics learning (Novitasari & Fathoni, 2026; Juraidah et al., 2025).

Furthermore, the Expectancy-Value theory developed by Eccles and Wigfield explains that learning motivation is influenced by students' beliefs in their abilities and the value they place on a learning task (Eccles & Wigfield, 2020). In geometry learning, students who believe they can understand geometric concepts and view mathematics as valuable tend to demonstrate higher learning effort. This contributes to increased cognitive engagement and the ability to understand spatial relationships and geometric representations. The findings of this study align with previous research, which found that mathematical motivation has a significant relationship with students' learning engagement and mathematical problem-solving abilities (Schukajlow et al., 2024). Simultaneously, visual learning styles and mathematical learning motivation demonstrated a significant influence on students' understanding of geometry material. These findings indicate that success in mathematics learning is influenced not only by cognitive factors in the form of learning preferences, but also by affective factors in the form of student learning motivation.

From a constructivist perspective, mathematical understanding is actively constructed through an interactive process between learning experiences, cognitive structures, and students' mental engagement (Piaget, 1974). In geometry learning, visual representations help students construct spatial concepts and geometric relationships, while learning motivation plays a role in encouraging student persistence, attention, and engagement during the knowledge construction process. Thus, cognitive and affective factors work in a complementary manner to shape students' conceptual understanding of mathematics. Furthermore, previous studies published in JES emphasized that the integration of learning motivation and appropriate learning approaches can improve students' learning effectiveness and conceptual understanding (Jonivan et al., 2026; Asriani et al., 2026). This finding is also supported by previous studies in JES indicating that learning motivation

significantly affects students' participation and achievement in mathematics learning (Novitasari & Fathoni, 2026; Juraidah et al., 2025).

Furthermore, the social-cognitive theory developed by Albert Bandura explains that the learning process is influenced by the reciprocal interaction between personal factors, behavior, and the learning environment (Bandura, 1986). In the context of this research, visual learning style represents students' tendencies in processing mathematical information, while mathematical learning motivation reflects the internal drive that influences the intensity of student engagement in learning. The interaction of these two factors enables students to build a more effective understanding of geometry. These findings suggest that effective mathematics learning requires considering the integration of students' cognitive and affective aspects. Therefore, mathematics teachers need not only to develop visual-based learning strategies but also to create a learning environment that can increase student motivation and engagement in the geometry learning process.

4. Conclusion

This study concludes that visual learning styles and mathematical learning motivation have a positive and significant influence on the understanding of geometry material in grade 10 students at MAN 2 Palu City, both partially and simultaneously. The results indicate that the stronger the visual learning style and the higher the mathematical learning motivation, the better the students' understanding of geometry material. The findings of this study imply that geometry learning needs to be designed to optimally utilize visual representations and be supported by learning strategies that can enhance students' mathematical learning motivation. Mathematics teachers need to develop learning that encourages active student engagement through the use of visual media, geometric illustrations, and a learning environment that supports learning motivation. This study is limited to two independent variables and was conducted at a single research location, so generalization of the results requires caution. Furthermore, this study used an ex post facto approach, so the relationships between variables cannot fully explain the causal relationship in depth. Therefore, future research is recommended to develop a more comprehensive research model that includes other variables such as self-efficacy, mathematics anxiety, learning strategies, and the integration of learning technology in developing students' mathematical understanding.

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