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HOTS Geometry Analysis on Critical Thinking and Numeracy Skills Reviewed Learning Style and Gender

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Abstract

Critical thinking and numeracy skills are important competencies for students facing challenges of the 21st century and era of industrial revolution 5.0. In mathematics learning, especially geometry, using Higher Order Thinking Skills (HOTS) questions is a strategic approach to developing these abilities. This study analyzes students' critical thinking and numeracy skills through HOTS geometry questions, reviewed by learning styles and gender. The research uses a quantitative descriptive method with a purposive sample of 26 VIII-grade students at SMP Negeri 1 Kota Bima. Results indicate that male students with visual learning styles achieved the highest scores in both skills. Visual learning styles were more effective in supporting numeracy skills, whereas auditory and kinesthetic styles supported critical thinking more effectively. ANOVA tests revealed significant differences in numeracy skills on the "making decisions" indicator by learning style (Sig. 0.047) and gender (Sig. 0.0291), and in critical thinking skills on the "inference" indicator by gender (Sig. 0.0265). In conclusion, learning styles and gender influence critical thinking and numeracy, with learning style having the more pronounced effect. Future research is needed to train students in answering HOTS questions to enhance both skills.

Kata Kunci: critical thinking; gender; HOTS geometry; learning styles; numeracy

INTRODUCTION

In the 21st century education era, several skills should be possessed by students in facing global development (González-pérez & Ramírez-montoya, 2022; Mutohhari, Sutiman, Nurtanto, Kholifah, & Samsudin, 2021). Critical thinking and numeracy skills are two of them that students must have. These skills not only play a role in academic problem solving, but also in real-life decision making. Critical thinking is crucial for dealing with complex problems (Shanta & Wells, 2022). Students are expected to be able to solve real-world problems that don't have a single definitive answer. Furthermore, numeracy is crucial for improving data literacy in the big data era. The ability to read and interpret numerical information is crucial (Grotlüschen, Desjardins, & Liu, 2020; Qiao, Chen, Guo, & Yu, 2024). Critical thinking and numeracy support each other. Strengthening both will produce students who think logically and analytically, and are skilled at solving numerical problems effectively. In line with current educational conditions that require students to be able to think at a high level (Siagian, Herman, Darhim, & Khairunnisa, 2022), not only teaching mastery of concepts, but also encouraging the application of knowledge in various life contexts (Mailani, Setiawati, Surya, & Armanto, 2022; Miranda et al., 2021; Primayana, 2020).

The formation of these skills has been carried out with various approaches and innovations by researchers, especially in the field of education. Habituation of students in facing challenges in the form of high-level questions is one of these approaches. High-level questions are known as *Higher Order Thinking Skills* (HOTS) (Gozali, Lie, Tamah, & Jemadi, 2021; Jannah, 2021). The development of HOTS-type questions is specifically designed to hone students' abilities to analyze, evaluate, and create, or at the highest level of thinking of each skill indicator (Saraswati & Agustika, 2020; Siallagan, Tambunan, & Sidabutar, 2023). In the context of mathematics learning, the application of HOTS questions is important to train students to think more deeply, critically, and creatively, especially in understanding and applying abstract concepts (Noor & Abadi, 2022; Tanudjaya & Doorman, 2020; Yazidah, Argarini, & Sulistyorini, 2020).

Geometry as a branch of mathematics has unique characteristics, which require visualization skills, spatial logic, and in-depth understanding of abstract concepts (Susanto & Mahmudi, 2021; Ziatdinov & Valles, 2022). Geometry material is one of the areas that is very potential to be applied to HOTS type questions. Geometry is considered to have great potential for application to HOTS (Higher Order Thinking Skills) questions, partly due to its high level of conceptual complexity(Suanto, Maat, & Zakaria, 2023). Geometry requires students not only to memorize formulas but also to understand the relationships between elements. Geometry also requires visualization and spatial representation, requiring students to be able to visualize both plane and solid shapes in their minds (Jablonski & Ludwig, 2023; Totikova et al., 2020). Finally, geometry demands the ability to apply concepts to contextual problems.

Through this approach, students are expected not only to memorize formulas, but to be able to construct new understanding and use it in various real situations or solve problems. This is directly related to critical thinking skills, as students are required to analyze problems in depth, evaluate various alternative solutions, and relate geometric concepts to everyday life contexts (Tursynkulova, Madiyarov, Sultanbek, & Duysebayeva, 2023). The process of building new understanding cannot occur simply by memorizing formulas, but rather through critical thinking activities such as examining the reasons for using certain formulas, identifying patterns or properties of shapes, and drawing conclusions and judgments based on strong evidence and logic. Furthermore, applying geometric understanding in real-world situations also trains students' numeracy skills, as they need to use numerical data, perform precise calculations, understand units of measurement, and interpret calculation results in the context of the problem at hand (Sidiq, Ayudia, Sarjani, & Juliati, 2023). Numeracy is not just a matter of counting skills, but includes the ability to use mathematical concepts effectively and rationally to solve practical problems. At least these two skills are needed for students to answer this challenge.

Based on the results of initial observations conducted on 32 eighth-grade students of SMP Negeri 1 Kota Bima, it was found that geometry learning was still dominated by lecture methods and routine practice problems without encouraging students to think at a higher level. When the teacher began to raise Higher Order Thinking Skills (HOTS)-oriented questions, such as asking students to

determine the area of the shadow region in geometric transformations or construct solutions to contextual problems involving the concepts of plane and spatial shapes, around 40% of students (13 students) showed a positive response. They began to discuss, put forward logical arguments, and connect geometric concepts with everyday life. This was seen when the teacher gave geometry problems that required analysis, as many as 78% of students (25 students) tended to wait for step-by-step explanations from the teacher and only 22% of students (7 students) tried to solve them independently even though the answers were not quite right. These findings indicate that the application of HOTS-based geometry problems and learning activities has significant potential in training critical thinking skills, characterized by students' ability to analyze problems, evaluate solutions, and construct logical arguments; as well as training numeracy skills, in the form of the ability to apply mathematical concepts to solve everyday problems correctly and reasonably.

Critical thinking skills will determine students' understanding of relatively abstract subject matter, such as geometry (İbili, Çat, Resnyansky, Şahin, & Billinghurst, 2020; Ramadhani, Ansori, & Suryaningsih, 2021). The reference is to Blom's taxonomy that critical thinking skills are at least at their three highest levels (Anggreini, Bharata, & Noer, 2022; Horváthová & Naďová, 2021). This condition allows students to survive and compete in the upcoming industrial 5.0 revolution. Fulfilling and preparing for this is the urgency that this research is presented. Students need to be trained or habituated in dealing with HOTS type questions as a step to form critical thinking skills (Aura Diva & Purwaningrum, 2023; Rohmah Hufnita Sari & Suprijono, 2022). Furthermore, numeracy skills are very relevant in learning geometry (Astuti & Supiat, 2023; Junaidi & Wulandari, 2024). Numeracy involves not only calculation, but also interpretation, analysis, and use of numbers or shapes in a meaningful context (Bolstad, 2023; Tout, 2020). The application of HOTS questions in geometry materials can be an effective means to measure, train, and even develop students' numeracy skills more comprehensively (Barokah, Wiharja, Sekarwangi, & Khoerunnissa, 2024; Budiarti et al., 2024; Heryani, Kartono, Wijayanti, & Dewi, 2023).

The implementation of HOTS questions as an approach in the formation of these two skills requires further analysis. The analysis is intended not only from individual student achievements. This research is intended to look at the factors of learning styles and gender of students. Previous studies have generally focused only on general student learning outcomes, without considering other individual factors such as learning style and gender. Learning style influences how students process information and solve problems, while gender is often associated with differences in math problem-solving strategies. Sari et al.'s (2019) study only assessed the influence of HOTS questions on mathematics learning outcomes without analyzing students' learning style preferences, while Prasetyo's (2021) study evaluated the effectiveness of HOTS questions without differentiating outcomes based on gender. Learning styles reflect students' preferences in receiving, processing, and remembering information (Fadhila, Agusdianita, & Desri, 2024; Sheromova et al., 2020). Some students understand material more easily through a visual approach, while others are more effective with a kinesthetic or auditory approach. These learning style variations have the potential to influence how students understand HOTS questions, especially in the context of geometry which relies heavily on visual and spatial representations (Darmayanti, Sugianto, Muhammad, Vitor da Silva Santiago, & Muhammadiyah Malang, 2022; Heong et al., 2020; Pipit Firmanti, Yuberta, Dimas Danar Septiadi, & Nurulzhia Rahma Nisa, 2024).

Another factor is gender, which is the basis for the differences in character possessed between male students and female students. Generally, there are differences in thinking styles and learning approaches between male and female students that can affect their response to questions or lessons (Aguillon et al., 2020; Cardino & Ortega-Dela Cruz, 2020). Another characteristic is that male students are more confident in numeracy-based lessons, while female students excel in verbal-based lessons (Nasamu, Oyunniyi, Qudus, & Saadu, 2024). These common characteristics have an impact on how they deal with HOTS questions that require the integration of both.

Several recent studies have examined the effectiveness of the application of HOTS questions in measuring or improving students' critical thinking skills or numeracy skills. Research that specifically analyzes the application of HOTS questions on geometry materials in measuring students' critical thinking and numeracy skills, by considering learning style and gender factors, is still relatively limited (Kania & Kusumah, 2025; Kania, Nurhikmayati, & Larsari, 2025). In fact, this combination is very

important to produce a more complete picture of the effectiveness of HOTS-based learning in the future. Moreover, to train and shape students' critical thinking and numeracy skills. The existence of some previous studies can be visualized through the following bibliometric analysis results.

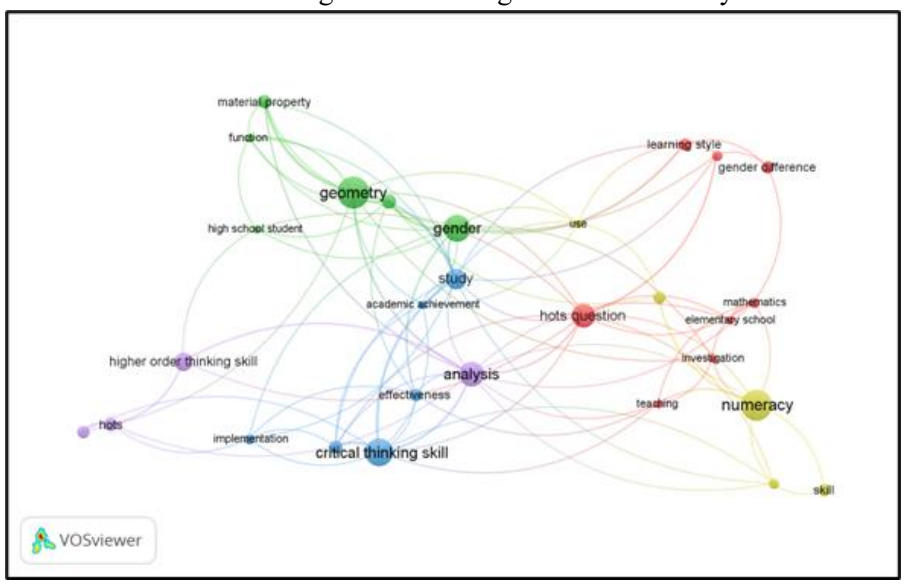

Figure 1. Visualization of the Relationship between Research Trends on HOTS

Referring to Figure 1, geometry material has the potential to be used to train critical thinking and the application of HOTS questions. Furthermore, the application of HOTS questions has a strong relationship with numeracy and learning styles, meaning that the use of HOTS questions in mathematics not only trains numeracy but also must consider students' learning styles. Gender is linked to learning styles and numeracy, indicating research interest related to gender differences in numeracy achievement and learning styles.

Based on these conditions, this study presents and seeks to analyze in depth how the application of HOTS-type questions on geometry material can measure students' critical thinking and numeracy skills, as well as how differences in learning styles and student gender affect these skills. The results of this study are expected to contribute to the development of mathematics learning strategies that are more adaptive, innovative, and responsive to the needs and characteristics of students. Teachers can design learning models and media that are more targeted. Improving the quality of mathematics learning and fulfilling 21st century skills are the ultimate expectations that need to be achieved.

METHOD

This study uses a quantitative approach with descriptive research type, aims to analyze students' critical thinking and numeracy skills through the application of *Higher Order Thinking Skills* (HOTS) type questions on geometry material, in terms of learning style and gender. The population in this study was 66 eighth-grade students at SMPN 1 Kota Bima. The The sample consisted of 26 students, selected using a purposive sampling technique. The sample selection was based on students who were accustomed to achieving high scores on daily tests. The research was conducted a week before the odd semester exams were held, so that students' abilities and understanding were still maintained or normal. The instruments used in this study include HOTS description test for geometry material, as well as learning style questionnaire based on VAK (Visual, Auditory, Kinesthetic) model. The HOTS questionnaire was used three days after students completed the VAK questionnaire to determine their learning styles. The general criteria for determining students' learning styles for visual learners are a tendency to absorb information better through images, graphs, diagrams, concept maps, or colors, and a preference for seeing explanations through illustrations rather than just hearing verbal explanations. Auditory learners are characterized by a tendency to understand material through oral explanations, group discussions, questions and answers, or listening to recordings, and remembering teacher explanations rather than written notes. Finally, for kinesthetic learners, the criteria are a tendency through direct practice, experiments, simulations, and

physical activities, and understanding concepts through real experiences and movement activities.

Data were obtained through the implementation of HOTS question tests that had been tested for content and instrument validity by mathematicians. Learning style questionnaires were given to classify students' learning styles. The data analysis technique used the help of SPPS 24 for descriptive statistics, oneway Anova test having previously fulfilled the prerequisite tests for normality and homogeneity, correlation test. Rasch Model analysis to determine the difficulty of items or students with the help of the Winstep application. Geometry HOTS Question Grid Table 1 on Critical Thinking Skills and Numeracy Ability Indicators.

Table 1. HOTS Geometry Grid Question Instrument for Critical Thinking Skills

Skills	Indicator	Question readings	Score Max
Critical Thinking	Analysis (CTI1)	1. Look at the following pictures of several flat and spatial shapes! Explain the differences and similarities in the properties of flat and spatial shapes in the form of triangles, cubes, and cuboids in terms of the number of sides, angles, and surface shapes!	10
	Evaluation (CTI2)	2. A student solves a problem about the combined surface area of a hemisphere and a cylinder by calculating the total area without subtracting the area of the closed base. Do you think this strategy is correct? Explain your reasons and provide a more efficient solution strategy if necessary!	15
	Inference (CTI3) (Marni, Aliman, Suyono, Roekhan, & Harsiati, 2020; Wale & Bishaw, 2020)	3. Create a new geometric shape with the following requirements: - Has more than 6 sides, - Consists of a combination of simple geometric shapes (for example: cube and pyramid), can be used as a storage container with one open side. - Describe and explain the reasons for choosing the shape.	25

Table 2. HOTS Geometry Grid Question Instrument for Numeracy Skills

Skills	Indicator	Question readings	Score Max
Numeracy	Reasoning (NI1)	1. Explain the relationship between side lengths, angles, and perimeter in an isosceles triangle. Use examples to support your explanation.	10
	Interpretation (NI2)	2. Given that a rectangle has a length of 3x and a width of x. If the perimeter of the shape is 64 cm, provide logical reasoning to determine the value of x and its area.	15
	Making Decisions (NI3) (Estrada-Mejia et al., 2020)	3. You are asked to choose a floor design for a classroom from the following three options: - A square floor with a side of 6 m, rectangular floor measuring 4 m x 9 m, triangular floor with a side length of 10 m. - The building will be used for learning activities with maximum capacity. - Choose the best design and explain reasons for your choice based on the calculation of area and efficiency of space use.	25

Referring to the maximum score of each indicator which results in the total score of each skill, this study determines the interpretation of the total score of each skill. The determination was made as a way of knowing the category of critical thinking and numeracy skills possessed by students.

Tabel 3. Interpretation of Students' Critical Thinking and Numeracy Skills Score

Score Range	Category
46-50	Very good
36-45	Good
26-35	Simply
0-25	Less

RESULTS

Validity of Critical Thinking and Numeracy Skills HOTS questions

First, the HOTS question instrument used in this study will be tested for validity. This validity test is on the content and empirical aspects of the HOTS question test results. First, the content validity test is based on the assessment results of two (2) mathematics evaluation experts. The results are shown in the following table 4!

Table 4. Content Validity of HOTS Instrument

Question Code	Skill Indicator	Assessed Aspect	Score		Average	Category
			Expert 1	Expert 2		
CTI1	Analysis	Compliance with critical thinking indicators	4	4	4.00	Very good
CTI2	Evaluation	Relevance of questions to real context	4	3	3.50	Good
CTI3	Inference	Ability to stimulate higher order thinking	4	4	4.00	Very good
NI1	Reasoning	Relevance to the context of numeracy in geometry	3	4	3.50	Good
NI2	Interpretation	Clarity of statements and clarity of instructions	4	4	4.00	Very good
NI3	Making Decisions	Accuracy of questions in measuring data-based decisions	4	4	4.00	Very good

Based on Table 3, the average assessment scores ranged from 3.50 to 4.00, all of which fell into the "Good" to "Excellent" category. Most of the questions, especially CTI1, CTI3, NI2, and NI3 obtained a score of 4.00, which indicates that the questions are very suitable for the skill indicators and the context of the geometry material. No questions were categorized as deficient or needing revision. Furthermore, the empirical validity data of the HOTS instrument test results will be presented.

Table 5. Empirical Validity of HOTS Instrument

Question Code	Skill Indicator	Correlation Value (r-count)	r-table (n = 25, α = 0.05)	Description
CTI1	Analysis	0.58	0.396	Valid
CTI2	Evaluation	0.65	0.396	Valid
CTI3	Inference	0.72	0.396	Valid
NI1	Reasoning	0.61	0.396	Valid
NI2	Interpretation	0.54	0.396	Valid
NI3	Decision Making	0.67	0.396	Valid

Using the Pearson Product Moment correlation test, the results of which are shown in Table 4, all items (CTI1 to NI3) have a correlation value (r-count) greater than the r-table (0.396), with values ranging from 0.54 to 0.72. Nilai tersebut termasuk dalam kategori sedang hingga kuat, menunjukkan item-item tersebut memiliki hubungan yang cukup tinggi/kuat.

Characteristics and Value Distribution of Students' Critical Thinking and Numeracy Skills.

The use of the Rashmodel test with the help of Winstep was carried out to initially determine the level of difficulty of HOTS questions for students. Furthermore, to determine the distribution of students' critical thinking and numeracy skills based on their gender and learning style. First, the level of difficulty of the HOTS items used is shown at Figuer 2.

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	JMLE MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMEASUR-AL CORR.	PTMEASUR-AL EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	DISPLACE	Item
4	7	26	.29	.48	1.04	.27	1.00	.07	.35	.37	69.6	73.0	.00	CTI1
3	8	26	.07	.46	1.11	.66	1.13	.62	.29	.39	65.2	69.4	.00	NI3
5	8	26	.07	.46	.97	-.11	.99	.05	.41	.39	73.9	69.4	.00	CTI2
1	9	26	-.14	.45	.92	-.50	.86	-.71	.48	.40	65.2	66.6	.00	NI1
2	9	26	-.14	.45	1.05	.39	.99	.02	.37	.40	56.5	66.6	.00	NI2
6	9	26	-.14	.45	.92	-.45	.99	.02	.45	.40	82.6	66.6	.00	CTI3
MEAN	8.3	26.0	.00	.46	1.00	.04	.99	.01			68.8	68.6	.00	
P.SD	.7	.0	.16	.01	.07	.43	.08	.39			8.1	2.3	.00	

Figure 2. Item Statistics: Displacement Order

Figure 2 shows that all items (CTI1, NI3, CTI2, NI1, NI2, CTI3) are statistically valid, are within a reasonable fit range, and have good discrimination power, or no items need to be removed or revised. All infit and outfit MNSQs were within the range of 0.92-1.13, meaning all items were within the limits of good fit (ideal range: 0.7-1.3). All correlation values (PTMeasure-Al Corr) were positive (0.29-0.45), indicating all items were consistent in measuring the same skill.

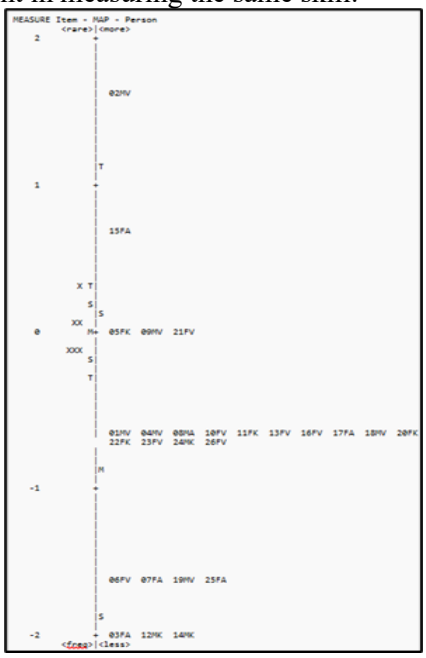

Figure 3. Person: Wright Map

The distribution of students' critical thinking and numeracy skills scores is spread between-2 to +2 logits, meaning that it is quite diverse, from very low to high. Skor kemampuan siswa berada di antara -2 logit (sangat rendah) hingga +2 logit (tinggi). It also shows the diverse abilities of students, with some having very low, low, medium, and even high abilities. This means that there is no "clustering" of scores at a single point (e.g., all low or all high), but rather a spread distribution. This diverse distribution indicates that the instrument used has good discriminatory power, as it is able to differentiate students' ability levels.

Description of Critical Thinking and Numeracy Skills of Students Based on Learning Style and Gender

The following table 6 to shows a comparison of students' critical thinking and numeracy skills scores on each indicator, along with their categories when viewed from gender and learning style.

Table 6. Mean Value and Category of Students' Critical Thinking and Numeracy Skills

Descriptives

	Student Gender	**Mean**	**Category**
Score Numeracy Indicators	Male	41.1000	Good
	Female	39.2500	
Score Critical Thinking Indicators	Male	39.7000	
	Female	40.9375	
	Learning Style	**Mean**	**Category**
Score Numeracy Indicators	Auditory	39.6667	Good
	Visual	42.0000	
	Kinesthetic	36.4286	
Score Critical Thinking Indicators	Auditory	42.1667	
	Visual	39.7692	
	Kinesthetic	40.2857	

Based on Table 5, that in terms of learning style and gender, students' critical thinking and numeracy skills are categorized as good. The specifics of the good category, when reviewed on each indicator, produce the following figure 4.

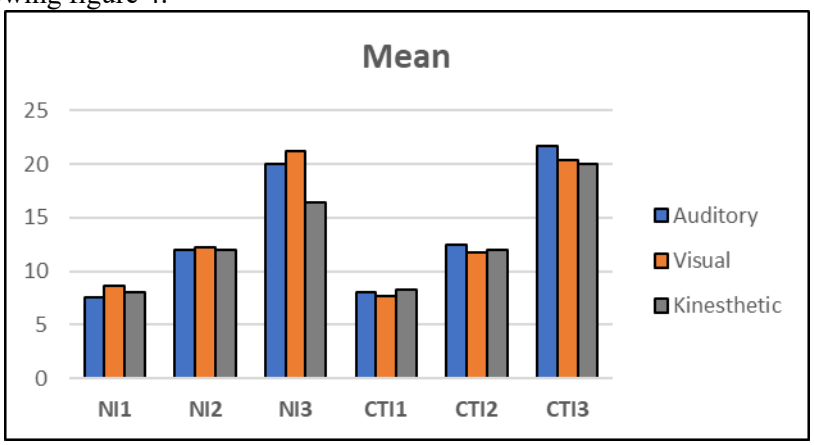

Figure 4. Comparison of Average Value of Each Indicator Viewed from Learning Style

The data first met the homegenity test to continue with the oneway Anova and *post hoc* tests.

Differences in Critical Thinking and Numeracy Skills of Students Based on Learning Style and Gender.

Anova test is used to determine whether or not there is a difference in student skills. The use of Post hoc further test is also able to show whether or not there is a difference to each skill indicator. Reviewing these differences in learning styles and gender. As a result, only on learning styles the post hoc test can be done. The prerequisite of homogeneity of research data is met, shown in Table 6.

Table 7. Data Homegenity of Each Skill Indicator

Test of Homogeneity of Variances

	Levene Statistic	**df1**	**df2**	**Sig.**
Numeracy Indicator 1	.103	2	23	.902
Numeracy Indicator 2	2.383	2	23	.115
Numeracy Indicator 3	1.485	2	23	.247
Critical Thinking Indicators 1	.348	2	23	.710
Critical Thinking Indicators 2	.316	2	23	.732
Critical Thinking Indicators 3	.829	2	23	.449

The significant values are all >0.05 so that the data is homogeneous and the Bonferroni post hoc test can be used.

Table 8. Anova Test Results Viewed from Learning Style

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Numeracy Indicator 1	Between Groups	4.205	2	2.103	.889	.425
	Within Groups	54.410	23	2.366		
Numeracy Indicator 2	Between Groups	.346	2	.173	.026	.974
	Within Groups	152.308	23	6.622		
Numeracy Indicator 3	Between Groups	102.747	2	51.374	3.441	.049
	Within Groups	343.407	23	14.931		
Critical Thinking Indicators 1	Between Groups	1.648	2	.824	.326	.725
	Within Groups	58.198	23	2.530		
Critical Thinking Indicators 2	Between Groups	2.192	2	1.096	.178	.838
	Within Groups	141.808	23	6.166		
Critical Thinking Indicators 3	Between Groups	9.936	2	4.968	.321	.729
	Within Groups	356.410	23	15.496		

Based on Table 7, there is a significant difference between learning styles on numeracy skill indicator 3 (making decisions). The decision-making indicator in numeracy skills includes the ability to reason quantitatively, make data-based decisions, and analyze graphs or statistics, showing significant differences between learning styles. Furthermore, a post hoc test was conducted to show in detail which skill indicators had different scores in terms of students' learning styles.

Table 9. Post Hoc Anova Test Results of Critical Thinking and Numeracy Skills Indicators in Response to Student Learning Styles.

Dependent Variable		(I) Learning Style	(J) Learning Style	Mean Difference (I-J)	Sig.
Numeracy Indicator 1	Bonferroni	Auditory	Visual	-.9487	.672
			Kinesthetic	-.3333	1.000
		Visual	Auditory	.9487	.672
			Kinesthetic	.6154	1.000
		Kinesthetic	Auditory	.3333	1.000
			Visual	-.6154	1.000
Numeracy Indicator 2		Auditory	Visual	-.2308	1.000
			Kinesthetic	.0000	1.000
		Visual	Auditory	.2308	1.000
			Kinesthetic	.2308	1.000
		Kinesthetic	Auditory	.0000	1.000
			Visual	-.2308	1.000
Numeracy Indicator 3		Auditory	Visual	-1.1538	1.000
			Kinesthetic	3.5714	.331
		Visual	Auditory	1.1538	1.000
			Kinesthetic	4.7253*	.047
		Kinesthetic	Auditory	-3.5714	.331
			Visual	-4.7253*	.047
Critical Thinking Indicators 1		Auditory	Visual	.3077	1.000
			Kinesthetic	-.2857	1.000
		Visual	Auditory	-.3077	1.000
			Kinesthetic	-.5934	1.000
		Kinesthetic	Auditory	.2857	1.000
			Visual	.5934	1.000

Critical Thinking Indicators 2	Auditory	Visual	.7308	1.000
		Kinesthetic	.5000	1.000
	Visual	Auditory	-.7308	1.000
		Kinesthetic	-.2308	1.000
	Kinesthetic	Auditory	-.5000	1.000
		Visual	.2308	1.000
Critical Thinking Indicators 3	Auditory	Visual	1.2821	1.000
		Kinesthetic	1.6667	1.000
	Visual	Auditory	-1.2821	1.000
		Kinesthetic	.3846	1.000
	Kinesthetic	Auditory	-1.6667	1.000
		Visual	-.3846	1.000

The use of the post hoc test is to find out in more detail the significant differences stated in the previous anova test results. Further review of critical thinking and numeracy skills is based on student gender.

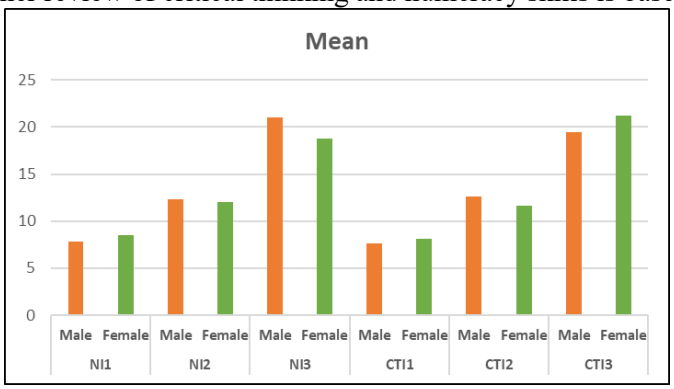

Figure 5. Comparison of Mean Values of Each Indicator by Gender

Statistical test data is needed to support Figure 5. Through the oneway Anova test in the following table 10.

Table 10. Anova test results in terms of gender

ANOVA

		Sum of Squares	Df	Mean Square	F	Sig.
Numeracy Indicator 1	Between Groups	3.015	1	3.015	1.023	.265
	Within Groups	55.600	24	2.317		
Numeracy Indicator 2	Between Groups	.554	1	.554	.087	.770
	Within Groups	152.100	24	6.338		
Numeracy Indicator 3	Between Groups	31.154	1	31.154	1.802	.0291
	Within Groups	415.000	24	17.292		
Critical Thinking Indicators 1	Between Groups	1.696	1	1.696	.700	.411
	Within Groups	58.150	24	2.423		
Critical Thinking Indicators 2	Between Groups	5.850	1	5.850	1.016	.323
	Within Groups	138.150	24	5.756		
Critical Thinking Indicators 3	Between Groups	18.846	1	18.846	1.302	.0265
	Within Groups	347.500	24	14.479		

Based on the results of the ANOVA test above, there is 1 (one) indicator each in each skill that has a significant difference when viewed from gender. The fact that there is no difference in students' critical thinking and numeracy skills encapsulated in HOTS questions when viewed from learning styles and gender, allows that each item of the HOTS question has a correlation. The correlation test was conducted to answer this assumption, the results are presented in the following table 11.

Table 10. Correlation Test Results of Each Skill Indicator Viewed from Learning Style and Gender

Control Variables			Numeracy Indicator 1	Numeracy Indicator 2	Numeracy Indicator 3
Learning Style & Student Gender	Critical Thinking Indicators 1	Correlation	.400	.271	-.330
		Significance (2-tailed)	.035	.200	.115
	Critical Thinking Indicators 2	Correlation	-.147	-.201	.326
		Significance (2-tailed)	.493	.345	.024
	Critical Thinking Indicators 3	Correlation	.152	-.126	.866
		Significance (2-tailed)	.480	.556	.036

This correlation is moderately positive and sig <0.05, indicating that the higher the critical thinking ability of indicator 1 (analysis), the higher the numeracy ability of indicator 1 (reasoning). These findings indicate that to improve students' numeracy skills, particularly reasoning, teachers need to train their critical thinking skills, particularly analytical skills. This is because numeracy reasoning is inseparable from the ability to analyze information and determine problem-solving strategies.

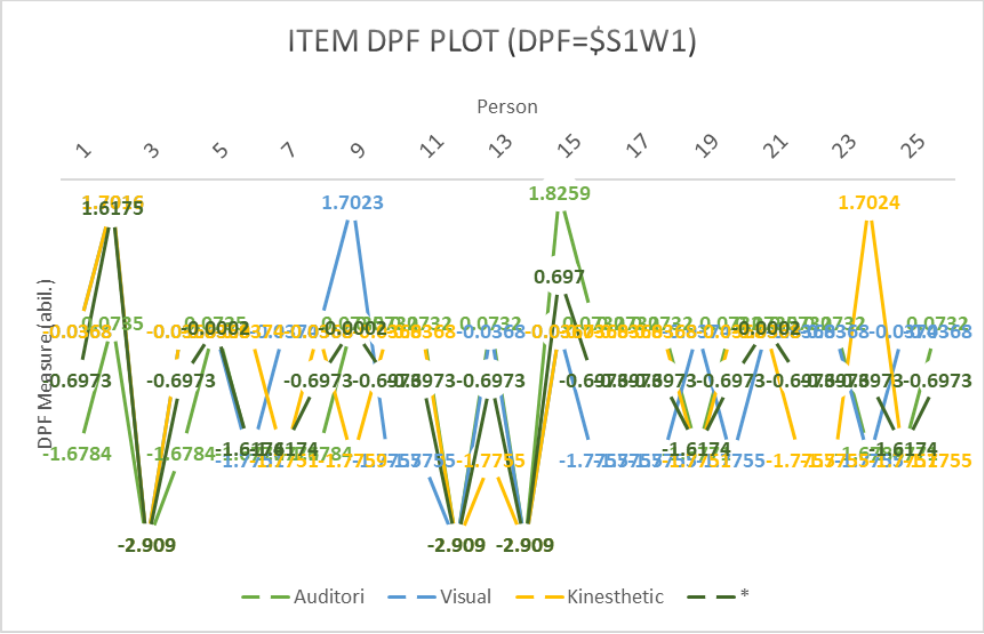

Figure 6. Variation of Student Skills Based on Learning Style

Based on Figure 6, reviewed based on the learning style of each student. Points with high values, for example 1.7023, 1.7024, and 1.8259, indicate that students with visual, auditory, and kinesthetic learning styles have higher skills in answering HOTS questions. Conversely, points with low values, for example -2.909 and -1.7755, indicate that the group of students with auditory/visual/kinesthetic learning styles struggles in answering HOTS questions, meaning they have less adequate critical thinking and numeracy skills.

DISCUSSION

The raters agreed that the questions were relevant to the learning objectives and HOTS indicators. All questions are declared content valid because they have met the criteria for suitability of indicators, clarity of sentences, and the relationship of the context of the problem with geometry and 21st century skills. These scores (Table 4) state that all questions are statistically valid and suitable for use to

measure the intended indicators. The high correlation indicates that the items have a strong relationship with the total score, which means that the instrument has consistency in measuring students' critical thinking and numeracy skills. Especially for NI3 (decision making) and CTI3 (inference), they even have the highest correlation value, which shows the greatest contribution in distinguishing students' ability levels. Overall, the HOTS items are empirically valid, none need to be revised or created, and are able to accurately measure critical thinking and numeracy indicators.

The measure values (Figure 2) ranged from-0.14 to 0.29. This indicates all items are at relatively similar difficulty levels (no extremes). Exact match (OBS%) averaged 68.8%, indicating that the model's prediction of respondents' answers was quite accurate. The final statement based on Figure 2, that all items (CTI1, NI3, CTI2, NI1, NI2, CTI3) are statistically valid, within a reasonable range of fit, and have good discrimination power, or no items need to be discarded or revised. The male student with visual learning style (02MV) had the highest skill score. Whereas 2 (two) male students with kinesthetic learning style (12MK and 14MK) and a female student with audiotory learning style (03FA) had the lowest skill scores. The majority of students are between-1 and 0 logits, such as 01MV, 04MV, 08FA, 18FV, 16FV, and so on. These majorities indicate that most students are at a medium average skill score. The conclusion is that participants' abilities varied so that the items used were challenging, but the majority were in the medium skill range.

This achievement (Table 5) indirectly shows that it is true that students as samples have faced HOTS questions. It also indirectly recommends the need for innovation in increasing the category to excellent. Figure 4 shows that visual learning styles are effective for numeracy skills, evidenced by excelling in each indicator. In contrastaudiotory and kinesthetic learning styles are effective for critical thinking skills. Audiotory learning style on CTI2 and CTI3 indicators, and kinesthetic learning style on CTI1 indicator. This finding indicates that students with certain learning styles are superior in dealing with complex numeracy challenges. Research by Sheromova et al. (2020b) shows that in complex tasks, appropriate learning styles can enhance comprehension. Visual learning styles, for example, more easily understand graphs and tables, which may explain their superiority in advanced numeracy such as decision making (Misnawati, Patandean, & Rahmaniah, 2024; Patriana, Sutama, & Wulandari, 2021).

A different condition is that there is no significant difference between learning styles on critical thinking skills in all indicators. Stating that learning style is not a determining factor in the development of critical thinking skills, be it at the level of analysis, evaluation, or inference. Supporting the statement of Kalo Timo, Lodia Musa, Julio, & Huko (2024) that critical thinking is a metacognitive skill that can be developed through explicit, collaborative, and reflective learning, regardless of each individual's learning style (Li, Liu, & Tseng, 2023; Rivas, Saiz, & Ossa, 2022). The development of critical thinking skills depends more on teaching strategies and habituation to logical thinking than adaptation to learning styles. Precisely on numeracy indicator making decisions, the details of which there are significant differences (Sig. 0.047) are between visual and kinesthetic learning styles. The difference is that students with visual learning styles are superior (4.7%) compared to students with kinesthetic learning styles. A new statement emerges that numeracy skills in terms of making decisions will be determined by students' learning styles, especially in students with visual learning styles or students with kinesthetic learning styles.

Figure 5 shows that in general, male and female students have equal abilities or there are no differences. Proof of this statement is through the frequency of excellence of male and female students who are equally superior in 3 (three) indicators of critical thinking and numeracy skills. Another statement is that in critical thinking skills indicator (CTI3) and numeracy skills indicator (NI3) which shows significant differences from the graph. Numeracy indicator making decisions Sig. 0.0291 ($p < 0.05$) which states that there is a significant difference between male and female students. This condition can be interpreted that one gender shows higher performance, as shown in Figure 3, namely the comparison of mean scores. According to researchers such as Lee, Wang, & Lim (2024) and Mafarja & Zulnaidi (2022), differences in student skills are not solely due to biological factors, but are influenced by sociocultural factors, teacher expectations, and the learning approach used. Critical thinking indicator (inference) sig. 0.0265 ($p < 0.05$) thus stating that there is a significant difference between genders. In

the inference indicator, differences can be caused by learning style factors, confidence in expressing opinions, or academic environment support (Luky & Thohir, 2025). This shows the need for a differentiated approach in critical learning, so that both genders get optimal space to develop.

In contrast to the reasoning and interpretation indicators in numeracy skills, there is no significant difference in gender. This is in line with the findings of OECD (2019) in the PISA report which states that differences in numeracy performance between men and women tend to be small and inconsistent, depending on the cultural context and learning strategies. A theory also states that both male and female students have equal opportunities in developing numeracy skills, especially when the learning environment is equal and inclusive (Adipat & Chotikapanich, 2022; Nortvedt & Wiese, 2020).

The statement that there is no significant difference is also attached to the analysis and evaluation indicators in critical thinking skills in terms of gender. At the analysis level (identifying information or distinguishing facts) does not differ between men and women and can be developed equally through active learning and open discussions (Syafiqul & Hanif, 2025). The evaluation level also shows no difference based on gender. Research by Junaidi & Taufik (2021) and Armadani & Budiman (2022) showed that if given an explicit teaching strategy, both men and women showed equal improvement in critical thinking.

A statement from several studies also confirms that numeracy is not just counting skills, but also the ability to reason logically which is closely related to critical thinking (Nursyifa & Masyithoh, 2023; Wulansari & Dwiyanti, 2021). Another significant positive correlation is that critical thinking indicator 2 (evaluation) is closely related to advanced numeracy, namely making10 decisions numeracy indicator. This is reinforced by the theory from Diana & Saputri (2021) which states that evaluation and inference are the core of rational decision making, which is indispensable in the context of high-level numeracy. This finding is reinforced by the PISA results (OECD, 2018) which show that students with reflective thinking skills tend to excel in complex mathematical reasoning.

Very strong correlation values occurred in critical thinking indicator inference with numeracy indicator making decisions. This achievement shows a deep relationship between high-level critical thinking skills and high-level numeracy skills. This correlation indicates that students who are able to perform complex evaluation and metacognition (inference), tend to have numeracy skills that integrate reasoning, data interpretation, and decision making. These results reinforce the findings from previous studies by Siller, Vorhölter, & Just (2024) and Mater et al. (2022) who stated that higher-order critical thinking is strongly related to the ability to solve quantitative problems and make logic-based estimates, especially in real-life and STEM contexts.

Differences in critical thinking and numeracy skills when viewed based on learning styles in each Student (Figure 6). The points with high values such as 1.7023, 1.7024, and 1.8259, indicate that students with visual, auditory, and kinesthetic learning styles, have higher skills in answering HOTS questions. Conversely, the points with low values, such as -2.909 and -1.7755, indicate that the auditory/visual/kinesthetic learning style student groups struggled in answering HOTS questions in the sense that they had poor critical thinking and numeracy skills.

CONCLUSION

Referring to the results of data analysis and discussion in this study, there are several outline points of findings. There are significant differences in students' critical thinking and numeracy skills when viewed from learning styles and gender. Specifically, students with visual and kinesthetic learning styles, which is indicated by visual learning style students having the highest scores in these skills. While the difference in gender occurs in the inference indicator (CTI3) and the decision-making indicator (NI3), although the average value between male and female students is equally superior in three (3) indicators. The correlation test results also found that the higher the analysis ability, the higher the students' reasoning ability. The same statement also applies to evaluation skills with the ability to make11 decisions, as well as inference skills with decision making. Overall, the achievement of skills obtained by students is in the "good" category. This achievement is the reason for the need for learning innovations such as in the form of learning models or media. An overview of the relationship between

students' critical thinking and numeracy skills with learning styles and gender can also be an initial reference for adjusting the learning approach taken by teachers in the future.

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